To the Right Honourable Anthony Greenwood, M.P.,
The Minister of Housing and Local Government.
And the Right Honourable William Ross, M.B.E., M.P.,
The Secretary of State for Scotland.

Gentlemen,

1. We were appointed by your predecessors in July 1964 with the following terms of reference:

> "To consider present methods of disposal of solid and semi-solid toxic wastes from the chemical and allied industries, to examine suggestions for improvement, and to advise what, if any, changes are desirable in current practice, in the facilities available for disposal and in control arrangements, in order to ensure that such wastes are disposed of safely and without risk of polluting water supplies and rivers".

We now have the honour to present our Report.

Chapter I—Introduction

2. We have met on 20 occasions and paid a visit of investigation to a large site in Essex where vast quantities of a wide variety of wastes have been and are being tipped. We accepted our terms of reference, though some of us felt that it might have been better to have substituted "manufacturers and users of chemicals" for "chemical and allied industries". The matter was not pursued, however, because it was thought impossible to delineate our field of enquiry precisely in a few words, however well chosen, and that our time would be wasted if we tried to do so.

3. One of our difficulties has been that there is no satisfactory definition of the word "toxic". We suppose that almost everything is toxic provided the concentrations and quantities are sufficiently great. But we also suppose that everything becomes non-toxic if the concentrations and quantities become sufficiently small. A few grains of unwanted arsenic would be toxic waste. But must a few tons of waste containing a few grains of arsenic also be classed as toxic waste? There was, surprisingly, a similar difficulty about the expression "solid and semi-solid". Dried sludge would plainly be a solid; but a liquid sludge disposed of where it would drain presents similar, maybe greater, risks, and it would have been foolish to have dealt with the one and not with the other.

4. These questions have not worried us unduly. We all have some technical knowledge and were never at issue with one another as to our field of investigation. Nevertheless, to clarify matters for other people, an explanatory note accompanied all invitations to submit evidence for our consideration.

The explanation stated in general terms that:

1. we would not consider radioactive wastes as such since they are provided for under special legislation;
2. we would not consider power station ash or similar waste products;
3. we would not deal with domestic refuse as such, since the risks to water supply by tipped refuse had been the subject of a report published in 1961;
4. we should deal with the possibility of disposing of toxic wastes with domestic refuse or on the site of domestic refuse tips;
5. we would not deal in detail with natural organic wastes the possible effect of which on water is of the same general nature as that of domestic refuse;
6. we should not deal with the disposal of spoil from general mining operations except possibly in special cases;
7. we should deal with sludges produced in the pre-treatment of effluents before discharge to sewers;
8. we should deal with oily wastes.

5. After we had been gathering evidence for some time it became plain that we would have to deal specifically with a matter which was quite outside any literal interpretation of our terms of reference, namely the question of liquid toxic wastes when they are disposed of in ways similar to those usually employed for solid waste, particularly by tipping. Disposal of liquid wastes is for the most part to sewers or streams (including estuaries), and this is adequately covered by public health and pollution prevention acts. But we found that considerable quantities of toxic liquids were being tipped with solid wastes. Such a method of disposal is not regulated by any specific legislation, but it could present a much greater threat to water supplies than tipped solid toxic waste. It appeared clear to us that we would be expected to deal with this matter and we did not think it necessary to ask you for wider terms of reference.

6. The pollution prevention acts speaks of "poisonous, noxious and polluting matter"; the adjective in our terms of reference is "toxic". We have not tried to distinguish precisely between these words, though we take it that "poisonous" and "toxic" are almost synonymous in their common or everyday use. Nor have we been concerned to prove that all the wastes we deal with are in fact "toxic" and, if so, to what. We have in fact been as much concerned about "polluting" (which also occurs in our terms of reference), but have deliberately avoided using the term "polluting wastes" since that would include house refuse, the disposal of which is at present being considered by another of your committees. Although we shall have occasion to mention house refuse and the possibilities of its polluting water supplies, we hope it will be plain that we have no desire to usurp the duties of that other committee. Indeed, we shall frequently use the expression "toxic waste" for no better reason than to indicate that it is polluting but not house refuse nor other waste of a similar general character.

7. When we were appointed the disposal of toxic solid wastes was to all intents and purposes a new subject for study. Many investigations have been made and papers (even books) written over several decades on the treatment and disposal of liquid industrial wastes, usually to sewer or stream. The matter of toxic gaseous wastes has also been the subject of study for more than a century because of the obvious importance of air pollution. There is no lack of people with expert scientific knowledge and practical experience of both these subjects. There have also been studies of the disposal of solid domestic waste and others of a similar character. But there was no body of knowledge on the subject of toxic solid waste or semi-solid waste disposal; no scientific and systematic studies of it had been made; few if any people were able to give authoritative advice on all aspects of the problem. There was, however, we believe, a general feeling among those concerned with the subject that, although it had given rise to little real trouble hitherto, widespread potential danger could exist and would increase, and that it was high time the subject was carefully examined so that the practice adopted could be soundly based to the satisfaction of all interests. The feeling spread to the general public at the time of the incident involving fluoroacetamide, which will be referred to later in the cases quoted in para. 53 as Case 15, and which was the immediate cause of our being called together.

8. Thus, none of us could claim to be expert on the whole subject, nor did we know where to find such a person. All of us, however, had knowledge of one or other aspect of the subject; all were interested in it, but from widely different angles. We considered, therefore, that our first task was one of mutual education.

Accordingly, our first few meetings were spent exchanging our own experience, explaining and discussing each other's points of view, and studying papers we ourselves had supplied. This we felt to be very profitable, and it gave us the general feel of the problem. Not until then did we think we could properly assess evidence from organisations with special interests in the problem.

9. We then invited such evidence, both through the press and specifically from associations and firms which we believed should have information to give and opinions to express. We had a good response, and the Appendix lists the organisations who submitted written evidence. Some of them we invited to give oral evidence, and those who did so are also indicated in the Appendix.

10. We do not attempt in this report to summarise the evidence we have received, though we would assure you we have taken full account of it. We thought it would be more helpful if our account were divided according to subject matter, bringing in evidence we believe to be reliable, wherever it came from, at points appropriate to that plan. We shall not usually acknowledge the source of the evidence we present; sometimes the same facts and opinions were expressed by several people and organisations, and names would be invidious. The conclusions reached, however, are our own, based as far as possible on knowledge and not put forward because other people also hold them, as no doubt some do.

11. The evidence we have received indicates that the technical position in Scotland is substantially similar to that in England and Wales, and we have not had to consider it separately. The legislative provisions and procedures however are not always identical and we shall summarise the relevant Scottish statutes later in this report. Generally, however, we do not draw attention to differences unless they are relevant to our conclusions.

12. We are a technical committee, and trust we shall not invade the realms of law, policy and administration more than technical men should. But, having considered primarily technical matters—present practice, possible developments, difficulties, dangers and technical methods of ensuring safety—we shall have to consider desirable general policy, the organisation necessary for its implementation, and whether the powers and controls which this may entail need to be authorised by law.

Chapter II—General Outline of the Problem

13. It is characteristic of all life that it takes in suitable raw materials, e.g. food and air, and converts them into products of value to itself or its species, e.g. heat, energy, body material, progeny. In doing so it inevitably produces waste material, e.g. carbon dioxide, faecal matter, which it must get rid of or perish. In the special case of modern human life the "intake" is of much wider character, and includes also fuel, clothes and the general appurtenances of civilisation. Our waste is correspondingly large and varied, and includes air pollutants, water pollutants, and the contents of dustbins. So far, a higher standard of living has always been accompanied by a larger volume of more complicated waste, and there is no sign that this will not be true in the future. This waste must be disposed of.

14. Industry is no exception to this rule. It uses raw materials, processes them to yield useful products, and is left with waste which may exceed 50% of the raw materials used. This is quite inevitable, and as industry increases in extent and diversity so will the waste increase in amount and complexity. It is a liability and must be disposed of.

15. For a particular man, his waste is disposed of satisfactorily if it is put somewhere where it will not affect him. So for a single firm. Even societies of men, so long as they remained agricultural, disposed of their waste to the land over centuries, if not millennia, with both satisfaction and profit. But bitter experience showed that for urban societies, and more recently for rural societies, it is far from easy to dispose of wastes so that they will not affect anyone else. Over the years, therefore, sewerage systems and treatment works have been constructed to deal with liquid wastes, refuse collection and disposal processes have been organised to deal with solid wastes, and more recently the Clean Air Acts (1956 and 1968) have brought domestic smoke under control.

16. Similarly, within a society it is not tolerable for a single firm to dispose of its wastes merely so that it will not affect its own activities; it must not adversely affect society either. Thus, the Alkali Act of 1906 and Order of 1966 enable industry to dispose of its gaseous wastes provided certain strict precautions are taken. For industry's liquid wastes the Public Health Acts, Pollution Prevention Acts and the Water Resources Act apply and make their requirements on industry while giving them certain rights. But for industry's solid wastes (and some liquid wastes see Chap. XX) no such complete body of legislation exists, and neither the duties nor rights of industry are fully defined.

17. It could be that this is no grave disadvantage for the greater part of industrial solid waste which is relatively inert. It is probable that the Planning Acts are sufficient to deal adequately with that, but that is not our concern. We have to deal with by far the smaller proportion of solid waste which is actively toxic, sometimes very toxic indeed, and for which we believe the Planning Acts are insufficient.

18. It is obviously in a manufacturer's interest to dispose of his wastes as economically as he can. It is also in the national interest that effort should not be unnecessarily or unprofitably diverted to waste disposal investigation or practice. Nevertheless, the national interest does not necessarily coincide with that of the manufacturer. It could well be in the national interest for the manufacturer to incur extra costs in treatment and disposal for which he gets no tangible return. He would much prefer to adopt the cheapest method of disposal which, for solid wastes, is usually tipping on land as near his factory as conveniently possible.

19. There are several dangers of indiscriminate and uncontrolled tipping of toxic waste which we must discuss, but at present it will suffice to mention the most insidious, the most difficult to assess and deal with, the one mentioned specifically in our terms of reference—the pollution of water supplies, particularly of underground water.

20. In this country we make vast use of underground water, particularly for public supply, and almost all of it percolates from the surface. It follows that in large areas of the country there is no absolute barrier between the land surface and the water lying beneath; this applies to such geological formations as chalk, limestone, sandstone and gravel. But the water near the surface is always impure—being contaminated with manure, fertiliser, decaying organic matter, etc.—while that drawn from underground is usually pure—in the sense of being wholesome, free from harmful and undesirable bacteria and organic matter, and fit to drink. There must therefore be natural barriers against pollution between the surface and the water table.

21. These may be broadly divided into three; a biological barrier, a physical barrier and a chemical barrier. The biological barrier is near the surface, where a large amount of biological breakdown of organic matter takes place. The physical barrier is the filtration which takes place while the water is percolating downwards to the water table and then being carried slowly along due to the hydraulic gradient. This is usually very efficient in removing bacteria and suspended matter of all types. The chemical barrier is base-exchange capacity which can hold back certain ions in water and allow others to go forward instead. It is not known how important this last barrier is.

22. Now it is clear that toxic matter tipped on permeable land may pass all these barriers. It may not be amenable to biological attack—indeed, below a tip of chemical waste the biological barrier may be destroyed altogether; if the toxic matter is in solution, filtration will not remove it; and unless it is a cation, base-exchange material will have no effect on it. There would then be apparently nothing to prevent such toxic matter reaching the underground water and, indeed, it would seem that it must reach it; but few water undertakings are equipped to analyse their sources for all possible poisons, none at present do it on a

routine basis, and certainly none is equipped to treat the water for the removal of poisons even supposing this were practicable. The attitude of water undertakings is therefore quite obvious and logical—toxic material ought not to be tipped on ground permeable down to the aquifer.

23. It may be dangerous to tip on impermeable land also, because from here the rain will wash it not to the underground water but into the surface water, and the river. As far as we have been able to discover, there have been far more cases of river pollution by toxic wastes than of underground pollution.

24. So what can be done with toxic wastes? Dumped at sea? Possibly; there is a place for that method of disposal, but it is expensive and unsuitable for some wastes; should we get value for money if we adopted the method more widely? Incineration? Possibly; again expensive; and not all toxic wastes will burn; some would cause gross air pollution; in some cases special incinerators would need to be constructed. Permanent safe storage? Possibly in a few cases; again expensive, and there would be a continual risk of an accident.

25. We must discuss all these matters in the light of the facts of the present situation, which are not what one might expect having read the few preceding paragraphs. Over the years vast quantities of industrial solid waste, much of it inert it is true, but some of it toxic and much more of it polluting, and the great majority of domestic and agricultural solid waste—all of it potentially polluting—has in fact been tipped, some on permeable and some on impermeable land. Yet the number of cases of significant river pollution from this cause has been surprisingly small and the number of cases of underground water being so impaired in quality as to be unfit to drink has been very small indeed, and has been largely confined to shallow wells.

26. These facts, discussed in more detail later, are mentioned now to show why it is that, since there is at least a theoretical danger to water attached to tipping toxic or polluting wastes on both permeable and impermeable ground, we do not immediately conclude that tipping should be discontinued. Experience suggests that this is quite unnecessary, and it would involve expenditure of a large amount of money since tipping is usually the cheapest method of disposal. Also, such a policy would be quite impracticable to operate and equally impracticable to enforce. It would be impracticable to operate (at least in the foreseeable future) because other methods of disposal for all wastes which could be toxic or polluting just could not be provided on the scale required. It would be impracticable to enforce because it could never be made too difficult for an unscrupulous person to tip a lorry load or a tanker load of toxic waste into a ditch or quarry without detection, and this could be very dangerous.

27. On the other hand, toxic wastes are increasing both in quantity and in complexity. This is an inevitable consequence of a rising standard of living. And in our view nothing is more certain than that, sooner or later, if indiscriminate tipping is permitted incidents of river pollution and sources of water becoming unfit to use will occur with increasing frequency until they are quite intolerable. And if control were left until then it might be decades before the trouble began to diminish, for it might prove virtually impossible to detect and intercept pollution already on its way from a tip to an underground source or water course.

28. In these circumstances neither impracticable idealism nor disastrous laissez-faire is the right policy to adopt. If either of them were right, we could say so immediately and end our report. But what is needed is a policy which, at the same time and to the greatest possible extent, combines practicability and safety. To determine what this should be has meant a long and searching investigation, and necessitated this lengthy report.

Chapter III—Types and Amount of Industrial Toxic Solid Wastes

29. We have referred to the impossibility of defining a toxic waste precisely. It is equally impossible in many cases to say quantitatively what the composition of any particular waste is. The manufacturer usually knows well enough the composition and properties of what he makes to sell; he has to in order to be able to sell it. But he has no similar incentive to find out the exact composition of the waste material produced in the manufacturing process. He will only do that (a) if he thinks it possible that the waste could be used profitably, either as it is or by further processing, (b) if he finds it to be necessary in order to dispose of it, or (c) sometimes purely as a research project.

30. Further, the composition of waste from a process may often vary more than that of the saleable product. That of the product may be fixed by specification, or maintained within certain limits by other requirements. But the raw materials used may vary in composition, and this variation must therefore be reflected in the waste rather than the saleable product. A waste might therefore contain or not contain, say, fluoride or arsenic depending largely not on the process in which it is produced, but on the impurities which might happen to be in the raw materials used.

31. Again, if a manufacturer had 1,000 tons of waste which was quite innocuous except that it contained 1 ton or 0·1% in all of, say, phenol, evenly dispersed in it, it might not occur to him that the phenol could do harm if the waste were tipped; but rainfall percolating through it could quickly wash out the phenol and it could be a threat to the quality of the water below. On the other hand, if he had 1 ton of phenol as waste he would certainly regard it as highly toxic, though if it were tipped concentrated in the middle of 1,000 tons of quite innocuous waste only a minute fraction of the percolate from the whole would come into contact with the phenol, and the total amount carried underground in unit time would be much smaller than in the first case. Underground water would be subject to less of a threat though it would be exposed to it for a longer time.

32. In these circumstances it is not surprising that when we asked for information about the type and quantities of toxic wastes we caused a good deal of head scratching. And we do not find it easy to present the information in a way we are certain will not mislead. We think it will be best to give first a list illustrating the ways in which the types of toxic waste have been described in the many communications which have been made to us, and secondly to record the return made by industry of wastes of several defined classes.

The following "toxic" wastes are among those which have been described to us:

Waste "chemical" slurry
Tarry liquids
Waste paint
Solid tarry matter
Oil-impregnated rubbish
Arsenic waste
Wastes containing cyanide
Beryllium wastes
Waste oil
Residues from pesticide formulations
Photographic waste
Carbides
Sludges containing copper, zinc, cadmium, nickel, etc., compounds
Aromatic hydrocarbons
Noxious organic solvents
White spirit
Lacquer
Lubricants
Chrome acid
Complex cyanides
Water-kerosene mixtures
Trichloroethylene
Oily slops from petroleum industry
Highly acid organic residues
Sludge from tar distillation
Phenol-formaldehyde sludge
Nicotine waste
Kier liquor
Spent sheep dip
Sulphides
Mercaptans
Acid tars
Alkaloid wastes
Arsenious sulphide
Fluorides
Plating sludges
Pickling sludges
Spent acids
Sludge from leaded petrol
Waste alcohols
Beta-naphthylamine sulphate
Diaminodiphenylmethane
Propyl iso-cyanate
Sodium acetylide
Chlorphenols
Chlorcresols

33. Also, as an illustration of what does happen, though not frequently, it may be mentioned that a few years ago a large organisation found itself with several

tons of surplus drugs to dispose of. Included in a list of no less than 230 preparations were strychnine, digitalin, mercurial and arsenical preparations, procaine and adrenalin. Similarly, it is by no means uncommon for a firm to have to dispose of a batch of highly toxic material simply because it fails to meet the required specification and is therefore unsaleable.

34. In 1966 at our request the Confederation of British Industry sent a questionnaire through member Trade Associations to individual firms asking for information about wastes generally and toxic wastes in particular. Answers were only requested, however, from firms which were thought to produce some toxic wastes, and therefore the figures given for other wastes do not represent the total by any means. Nevertheless, the information given about costs, methods of disposal, etc., is probably fairly representative, and we shall quote where necessary from the overall figures which accompanied the evidence of CBI. The detailed returns, of course, were confidential to the CBI.

35. The questionnaire requested that the solid and semi-solid waste produced by firms should be classified into five categories. In Table I these are given exactly as in the questionnaire, and it will be seen that they are qualitative descriptions. It should also be mentioned (a) that it was left to the firms to do the classification with only minor assistance from "explanatory notes" supplied with the questionnaire, (b) that the description "Indisputably toxic wastes" is calculated to exclude from this class everything about which there could be doubt as to whether it deserved the adjective "toxic" or not, and (c) that the instruction was to include a waste in one category only. Thus, if a waste was clearly a flammable process waste it would be placed in that category and not in the toxic waste category, though it might in fact be toxic as well. It seems likely, therefore, that the figures for toxic waste are on the low side.

36. Bearing in mind all these shortcomings, however, the table is presented as being as good an estimate of quantities as we could possibly expect to get and a most valuable source of information as to the method of disposal of industrial wastes of different types. A few comments will highlight the most interesting facts brought out.

37. Firstly, quite apart from uncertainties caused by difficulties of classification, it is plain that quantitative interpretation is made more difficult by the fact that of the grand total weight half is slurry including its water content. Thus, if the indisputably toxic waste is considered as a proportion of the grand total it is less than 2%, but if it is considered as a proportion excluding slurry it is nearly 4%. If the acid and caustic and the flammable wastes are also classed as toxic (as they could easily be) then the proportion excluding slurry is 14%. Perhaps the most that can be said with certainty is that the annual production of toxic solid and semi-solid or oily wastes in Britain is some hundreds of thousands of tons. This gives a measure of the size of the problem, a factor which was unknown at the time we began our work. This is an order of magnitude or so smaller than the total weight of solid waste produced by the industries surveyed, and much smaller still as a proportion of the total production of industrial refuse. It is only necessary to bring to mind the production of ash by the electricity industry and the spoil produced by the various mining industries to realise that this is true. The annual figure for the production of house refuse, for comparison, may be taken as 14 million tons, though this includes some "commercial" refuse.

TABLE I

Industrial Solid and Semi-Solid Wastes
Total Quantities in Tons/Year

Number of Premises included in Survey: 1186

Type of Waste	*Surface Tips*		*Mine-shafts*	*Incinera-tion*	*Disposal at sea*	*Contractor. Methods Unspeci-fied*	*Slurry, etc., pumped to settlement lagoons**	*Other*	*Total*
	Local Authority	*Other tips*							
General factory rubbish uncontaminated by process wastes	120,296	669,437	—	89,688	250	259,455	—	18,991	1,158,117
Relatively inert process wastes . .	238,789	1,597,333	863,140†	6,934	173,639‡	453,828	5,601,380	238,450	9,173,493
Flammable process wastes . . .	5,612	52,321	2,700	19,141	252	47,840	—	878	128,764
Acid or caustic wastes . . .	17,228	244,714	—	4,257	50	47,324	113,000	2,784	429,357
Indisputably toxic wastes . . .	1,457	149,213	3	1,173	5,981	42,294	—	1,556	201,677
TOTAL FOR DISPOSAL	383,382	2,713,018	865,843	121,193	180,172	850,741	5,714,380	262,659	11,091,388

NOTES: * includes weight of water
† includes 830,120 tons of aqueous slurry
‡ includes 160,000 tons of slurry

38. It should be mentioned here that the figures in Table I include the water content of slurries (as noted), and no doubt of some liquid (oily or aqueous) wastes, flammable wastes and acid or caustic wastes; they do not, however, include the generality of those aqueous wastes which are now disposed of by tipping. We shall devote a special chapter to them.

Chapter IV—Present Methods of Toxic Solid Waste Disposal

39. Unless otherwise prevented, all gaseous wastes enter the atmosphere as soon as they are produced and are then dispersed completely. Similarly all liquid wastes, unless otherwise prevented, end up in the sea, though they take longer—in some cases very much longer—to reach their final destination, and in a few cases they may never reach it. By contrast solid wastes, unless otherwise provided for, would stay where they are produced. This is usually intolerable, and they must be shifted to places where they are not in the way. In practice, and for industrial solid waste, this has meant transporting to the nearest land available and thought by the firm to be suitable for the purpose and tipping the wastes on the surface. There, apart from any decomposition and leaching that occurs, they remain indefinitely, though they may become covered with vegetation and in some cases may eventually blend with the landscape.

40. It is not surprising, therefore, to find from Table I that tipping is the predominant method of disposal of solid refuse from industry producing toxic wastes. To bring this point out from the table it is necessary again to neglect the slurry pumped to settlement lagoons (but not the acid and caustic slurry), though this is in effect tipping on land, and the slurry disposed of to sea and to mineshafts. It is also thought fair to assume that the unspecified contractor methods are also surface tipping. On this basis about 88% of all the refuse covered by the table is disposed of on to permanent tips. The figure for the indisputable toxic wastes is 96%, for the acid or caustic wastes 72%, and for the flammable waste 82%. Whether the differences between these figures are significant or not is not known, but at least it seems justifiable to conclude that toxic wastes, particularly "indisputably toxic wastes" are disposed of by surface tipping to just as great an extent, proportionately, as other less objectionable waste.

41. It is interesting to compare the proportion of each type of waste disposed of to tips of local authority, other tips and "contractors tips", again on the assumption that contractors methods are in fact tips. Table II gives percentages of the total tipped material in each case.

42. It is plain that local authority tips play but a minor part in the final disposal of the chemical industry's waste, and the more objectionable the waste the smaller the part they play. This is certainly a prudent policy on the part of local authorities, but if it should be that local authority tips have been more carefully chosen from the safety angle than industrial tips it is not a policy calculated overall to give the safest disposal. We have, however, no evidence on this point.

TABLE II

Class of Waste	*Per cent tipped to*		
	Local Authority tip	*Other tip*	*Contractors*
Factory rubbish	11·5	63·8	24·7
Inert process wastes . . .	10·4	69·7	19·9
Flammable wastes	5·3	49·2	45·4
Acid and caustic wastes . .	5·6	79·1	15·3
Indisputably toxic wastes . .	0·8	77·3	21·9

43. On the whole, industry makes more use of contractors than of local authorities but, with one exception, makes its own arrangements not involving contractors for the disposal of 60–80% of all the solid wastes it produces. Contractors are used for 15–25% of each class, with no significant variation with character, though with the same exception. This is that contractors undertake to dispose of nearly 50% of the flammable waste. The significance of this is debatable.

44. It will be seen from Table I that little use is made of incineration, except for general rubbish, of which less than 10% is burned (largely, it is thought, to reduce its bulk), and for flammable process wastes, of which 15% is burned. Although this figure is greater than the corresponding one for all other classes of waste, it still seems very small in view of the fact that the class to which it relates is by definition flammable. One would think that burning would be the safest method of disposal of such wastes, though in some cases air pollution might be a problem and in a few it might be difficult to dispose of the residue.

45. Only about 0·5% of the indisputably toxic waste is incinerated. This again is a surprisingly low proportion. By no means all of it is combustible, of course, and not all is detoxified by being brought to a high temperature, but one would have thought that incineration would present a complete and final method of disposal in a considerable number of cases.

46. Little need be said about other named methods of disposal. Very little of the waste under consideration is disposed of to sea and, if we again ignore aqueous slurry, it is mainly the very highly toxic waste; in these cases it appears that the need for vast dilution of the waste to render it non-toxic is appreciated; even so, sea disposal only accounts for 3% of the total of such waste possibly owing to the cost. Mineshafts are very little used, and mainly for slurry. It is understandable that they should be used for semi-solids rather than solids, because it is a better use of disposal space to fill up the adits and galleries which the tipping of solid wastes down the shaft would block up.

47. We shall be discussing the relative merits and optimum uses of the various methods of disposal later. It might be pointed out here, however, that there is not a great deal of evidence in Table I that the more dangerous wastes are more likely to be disposed of in the safer ways—taking incineration and barging to sea as being intrinsically safer than tipping. We hesitate to draw any conclusion from this, however, because we cannot eliminate other variables. It is more than likely that some relatively inert wastes are disposed of in unnecessarily safe ways because these happen to be the most convenient; it may also be that some more

dangerous wastes are disposed of in ways not to be commended because safer ways are not available within reasonable distances and at reasonable cost.

48. On the question of costs, CBI derived some data from statistical examination of replies to their questionnaire, and submitted the overall results to us with a great deal of reserve and many reasons why they might be inaccurate and probably misleading. We accept that they had every reason for substantial reservations, and we do not think it would be useful to reproduce the figures here. But some indication of the amount of money involved is always a help in assessing a problem, and we hope the following reasoning is not too far from the truth.

49. It was noted that on the average somewhere near 10% of firms who had to dispose of solid waste did so at a cost exceeding £5 per ton. The total of toxic waste, including acid and alkali wastes and flammable wastes, was also about 10% of the whole (excluding the slurry, or most of it). There is no evidence, as far as we know, which could possibly identify this 10% of toxic waste with the 10% which cost more than £5 per ton to dispose of but, in spite of what has been said above, it is likely that a dangerous waste would, on average, cost more to dispose of safely than one which is not dangerous. Equating the two 10 per cents, then, and taking the solid toxic waste at between 300,000 tons and 600,000 tons per annum, gives us a total cost of greater than £1½ to £3m per annum—say between £2 and £4 million. Let it be emphasised that this is thought only to give the order of the true cost, i.e. it probably lies between £1 and £10 million per annum.

Chapter V—Instances of Water Pollution from Tipped Toxic Wastes

50. We have already drawn attention to this country's dependence for public supplies upon water from underground. Generally, this is reliable in quantity and excellent in quality. It is commonly quite free from coliform organisms (indicators of possible pollution with harmful bacteria) and is clear, cool and free from taint. Although perfectly safe for drinking it is nowadays the custom to chlorinate it "just in case". Sometimes, however, the water at source does contain some coliform organisms, either occasionally or regularly, and chlorination is not only desirable but quite necessary. It is also necessary that it should be proved effective and should not fail. This means much more elaborate apparatus and control but, even so, such waters are not subjected to any treatment which would remove "toxic" compounds from them, nor could such treatment plant be provided quickly if it were needed. Treatment facilities involving precipitation and filtration are quite the exception for underground waters. Accordingly, it is vitally important that they should not become contaminated.

51. No one will deny the importance of keeping rivers unpolluted either, particularly those used for public water supplies, but the degree of importance is a good deal smaller for a number of reasons. First, the point of abstraction may be so far downstream of the point of pollution that a good deal of self-purification may take place before the contaminated water is withdrawn for use. Secondly, a river generally drains water from a vastly greater area than any given well or borehole, so that the same amount of pollution is diluted a great deal more if it enters a stream than if it contaminates an underground supply. Thirdly, pollution of a river can in general be more quickly recognised and more easily traced and eliminated than pollution of a well or borehole. Fourthly, no river water is put into supply without "full" treatment, in which there is at least a chance that toxic materials will be removed by the treatment normally given or by the use of special reagents in special circumstances, but this should not be relied upon.

52. Accordingly, we have enquired more carefully into cases of ground water pollution from toxic wastes than we have about river pollution. Moreover, it seems likely that river authorities, to whom we are indebted almost entirely for case-histories of river pollution, have ignored discharges or seepages which are trivial to them but which could have seriously polluted a supply drawn from underground. Even so, the most obvious conclusion from the list below is that cases of underground pollution are much rarer than those of river pollution.

53. We made extensive enquiries from river authorities, water supply authorities and local authorities, both privately and officially, about cases where actual pollution of water has occurred from tipped toxic wastes and related products. We give below a selection from cases quoted to us which illustrate the sort of problem which keeps cropping up in this country

Case 1. Pollution of a supply well with dissolved iron. This can hardly be called toxic pollution, but had toxic substances been dumped in the same way very dangerous contamination would certainly have occurred. It is therefore worth mentioning. Waste materials, including iron turnings, house refuse and partially burnt carbohydrate material, had been tipped into a wet gravel pit only 70 yards from a well station, and it was known that the two were in more or less direct communication with each other. The iron dissolved, presumably in acid generated in the decomposition of the organic matter, and entered the water.

Case 2. A 6-acre gravel pit had been partly filled with miscellaneous sludges and oily wastes. Some years later a borehole drilled nearby gave water with a Biochemical Oxygen Demand of 4,000 mg/1 (about 10 times as great as crude sewage). The borehole was drilled for testing purposes and not intended as a source of water. No natural stream or ground water which is used in the area has been affected at all, and there may be a clay seal preventing spread of pollution.

Case 3. A tip filled with sewage sludge, refuse and chemical sludges gives a polluting drainage which will not respond normally to biological oxidation, presumably because of its content of "toxic" matter.

Case 4. Shallow wells near an industrial tip yielded water which was undrinkable because of phenol contamination.

Case 5. Liquid alkali waste tipped close to a stream polluted it.

Case 6. A similar instance with acid wastes.

Case 7. Tipped tar distillation sludge polluted a stream.

Case 8. Oily petroleum wastes tipped into a quarry escaped through fissures and polluted a stream.

Case 9. Chemical wastes tipped down a mineshaft polluted a spring.

Case 10. Waste from Leblanc process tipped 80 years ago still drains liquid containing sulphide.

Case 11. Buried cyanide waste polluted a stream.

Case 12. Dieldrin from a sheep dip disposed of by soakaway polluted a stream.

Case 13. Tipping of chrome waste in a quarry polluted wells constituting a small private water supply.

Case 14. Shortly before Christmas 1968 complaints began to be received of a chemical taste in a water supply in the north of England, and some days later a dump of a few tons of apparent waste material was found in a disused quarry adjacent to a road within the gathering ground of one of the reservoirs. The waste material was found to contain large quantities of phenol, a fact which was an adequate explanation of the taste of the water. In spite of the prompt removal of the waste and some of the surrounding soil a concentration rising to 3mg/l occurred in the raw water, which continued to be tainted for some time.

Case 15. During May and June 1963, several sheep and cattle and a foxhound died, and many cattle became seriously affected, on two farms close to a factory producing rodenticides and pesticides. The drainage from the factory led into a succession of ponds to which the animals had unrestricted access, and from which they are therefore likely to have drunk. Investigations showed that a field on the site was a dumping ground for large metal drums and canisters, many of which had rusted away, their contents seeping into the ground. Residues from the manufacture of fluoroacetamide were also dumped on the site, and percolated into the drainage ditches leading to the farm ponds. Veterinary evidence indicated the assimilation of fluoroacetamide compatible with the animals having drunk contaminated water. Ditches and ponds were dredged and the sludge deposited on a site behind the factory. All sludges and contaminated soil were subsequently excavated, mixed with cement, put into steel drums capped with bitumen, and dumped at sea beyond the Continental Shelf. The presence of fluoroacetamide in the soil and associated water samples was prolonged, with very low but significant levels persisting, and delayed the resumption of normal farming for nearly two years.

Case 16. In 1967, water for public supply abstracted from a river in the south of England was the occasion of much public complaint of objectionable tastes in wet weather. This was found to be due to phenolic contamination, insufficient to affect stream-life, the origin of which was the run-off from an industrial waste tip near a tributary some 9 miles upstream of the intake. A good deal of the tipped waste was removed and the contamination thus was reduced, but treatment of the water with chlorine dioxide, which removed the taint, was necessary for some time.

Case 17. Late in 1969 a case occurred in North Wales of a large number of drums containing liquid and solid chemicals alleged to have been tipped without authorisation. It is understood that the contents were held to have presented a severe fire risk and might also have caused water pollution. At the time of writing the matter is *sub judice*.

54. Many instances of pollution of groundwater supplies on the Continent and in the USA have been cited in the literature, but these have had particular reference to the discharge or spillages of liquid effluents or other liquid materials into the ground, watercourses, or bodies of water. Typical sources of pollution of groundwaters are: septic tanks, leaking sewers, flood waters and other poor quality surface waters, mine waters and solids stored or sludges spread on the surface. It appears that some chemicals can percolate through clayey sediments into underlying aquifers. References have been made to tips being a possible source of contamination of groundwater, emphasising that once established they cannot be removed, and suggesting that only two methods of groundwater protection exist: (a) diverting the groundwater to bypass the tip, and (b) the boring of wells between the tip and supply wells to draw off the contaminated water leached from the tip. Examples of sources of contamination include: phenol from waste discharged into a tip; the discharge of gas liquor on land; and pollution by flooding of refuse tips. So far as this country is concerned we believe the list in the previous paragraph to be reasonably representative, and it also

includes a substantial proportion of all cases notified to us—those omitted are largely duplicates of those included. We also believe that three generalisations which the list suggests are significant and therefore worth mentioning and discussing briefly.

55. In the first place, so far as we know, there has been no significant pollution due to tipped "toxic" wastes of drinking water from underground sources supplied by water undertakings. In a few isolated instances small private supplies, usually shallow wells, have been affected and needed replacing. A number of cases of rivers being polluted have also occurred, but on the whole they have been surprisingly few and, though disturbing, have not been sufficient to interfere seriously with the use made of rivers, including, in some cases, water supply. The degree of pollution of rivers from tipped toxic waste (indeed, from tipped wastes generally) is extremely small compared with that caused by direct discharge of sewage and liquid industrial effluents. These are facts which must be noted and taken into account; but it must be remembered that it is possible that some pollution from tipped solid waste not amenable to biological purification may already be in the ground making its slow but inevitable progress towards a water supply source which it will ultimately reach even if tipping were to stop forthwith, [but see paras. 144–148 and also para. 179.] There is therefore no room for complacency.

56. Secondly, pollution of streams is more frequent than pollution of ground water pumped from aquifers. This may be because such contaminated water reaches the surface and possibly enters the stream while still relatively concentrated, as explained above. It may also be due to the fact that tips are often situated relatively close to streams. Also, the distance a waste must travel through rock to reach a borehole would probably on average be much greater than the distance to a stream, and this will allow both time and opportunity for purification en route. Finally, the continued non-contamination of ground water may well be due to the vigilance of water authorities which, in their day-to-day activities, are on the lookout for possible sources of pollution and taking such action as they may to prevent it.

57. Thirdly, pollution of small shallow underground sources occurs much more often than does that of large ones. Again, this may be due partly to the action of water undertakings protecting the larger ones—the smaller ones are often sources of private supplies. Also, the distance over which the pollution must travel to a deep source is often greater than to a shallow source, allowing more purification. But there is also the fact of much greater dilution where a large source is concerned. A given amount of pollution travelling underground will have only one-tenth the effect on a million gallon per day source which it would have on one yielding 100,000 gallons per day. We believe this to be an important point, and we shall return to it later. It is clearly an important factor in any attempt to quantify a risk in any given circumstances.

Chapter VI—Other Risks of Tipping

58. Our terms of reference pick out water pollution as the main risk of disposal we have to consider. This is because of the insidious nature of the risk and the widespread repercussions if pollution were to occur, but it does not absolve us from considering other risks. We shall not deal with them in detail, because they are generally more obvious and need the application of common sense rather than expertise to avoid them. In this section we are dealing with tipping only.

59. One obvious risk is that of fire. It is not impossible for two different types of waste to react to initiate combustion spontaneously. More commonly a waste is merely flammable, and unless properly dealt with would constitute a fire risk at many tips. A flammable waste liquid which could be lighted by a match, for instance, could serve to set alight a whole tip which would otherwise not have responded to ignition in that way. Fires, of course, should not be allowed to break out at any tip. In the past they have caused a great deal of nuisance in several ways. But fires at tips receiving toxic or polluting wastes are also objectionable on the grounds that if water is used for extinguishing them it may well dissolve toxic matter and carry it rapidly into the ground to give a far greater hazard to underground water than would otherwise have been the case. Indeed, a fire at a non-toxic tip may produce toxic materials which were not there before but which may then endanger water. This has actually happened at a dump for old tyres—one would not normally call old tyres toxic waste.

60. Some industrial wastes may present the risk of explosions which may, of course, be followed by fire. Others may give off poisonous fumes, particularly if they catch fire or if wastes deposited nearby are allowed to burn. Or they could give off poisonous fumes or gases if allowed to mix with other wastes, for example acid wastes. Even if not poisonous the smell generated by certain wastes or mixtures of wastes could lead to short or long term complaints for which the remedy could be most expensive.

61. Some wastes can be dangerous to handle because of their effect on skin. One cannot assume that skin contact will not occur after tipping unless the waste is immediately and deeply covered. Trespassing, particularly by children, is difficult to prevent entirely, and some of us doubt if there are such things as unclimbable fences. In a few cases toxic waste can be "spread" by animals.

62. Consideration may also need to be given to the future effect of the waste, if it is not harmlessly diluted or broken down. Will it sterilise soil indefinitely? If so, should it be so placed that it will never come into contact with surface soil?

Would it be a positive danger if ever the tip were excavated? If so, then its proper place is not in a tip which is likely to be excavated in the future, and so on.

63. These factors are not always easy to assess. Some of them, like fire and explosion, are more likely to be immediate than remote dangers, but with others the converse is the case. Experienced tip operators are likely to be well aware of the problems, and over the years they should have gathered a good deal of practical experience of how to deal with them effectively. They might not be able to deal with long term risks so successfully, though even here, with knowledge of what the ultimate fate of the tip is likely to be, a knowledgeable operator could do much to ensure that it would finally become innocuous.

64. It is plain, therefore, that a variety of other risks in addition to that of water pollution must be considered when deciding if and where to tip a particular waste. Nonetheless, it would appear that if the pollution risk is or could be made so small as to be ignored, then most other risks could usually be avoided at not too great an expense by skilled operation.

Chapter VII—Other Methods of Disposal

65. Table I (para. 35) brings out the predominance of tipping as a means of disposal of solid industrial wastes, including toxic ones or others which are dangerous in some way or other. It follows that there is no need in this largely factual part of the report to say much about other methods of disposal, but since these could in large measure eliminate the risk we are mainly concerned with, namely pollution, they certainly deserve a mention here and will be dealt with in more detail later. Of these methods incineration, the use of mineshafts and disposal to sea are mentioned in Table I. They avoid pollution of rivers and drinking water in three quite different ways.

66. If toxic wastes can be burned then the toxicity is either destroyed by decomposition, or dispersed to the atmosphere, or concentrated in the residue, usually in a less soluble or less toxic form. For organic toxic wastes which would leave no residue or a non-toxic one, disposal would be complete and, if atmospheric pollution could be avoided, safe. It is a process which is used to some extent, and is likely to develop even without our encouragement. In some cases use can be made of house-refuse incinerators, but sometimes purpose-built incinerators will be needed, which, we are told, are being developed by some contracting firms.

67. The safe and successful use of disused mineshafts really depends upon their being both deep and dry. They can then safely be assumed to be below the level of ground water in the area and completely cut off from it. Nothing short of major earth movements would bring about a hydraulic connection, and even then the water would flow towards the waste and the waste would not contaminate water being pumped. Given these conditions, and good operation to avoid fumes, fires and toxic gases, such mineshafts (and probably the mines themselves) could be used to great profit; probably it is their most rewarding use now that mining has been abandoned. They could receive wastes which it would not be safe to tip anywhere. They do not occur frequently to say the least, but one large one in the Midlands is now being exploited with the permission of the river authority.

68. Some mineshafts not having the properties mentioned above are also used for waste disposal. It will have been noted that para. 53, Case 9 records an instance of stream pollution from one of them.

69. Disposal at sea clearly takes toxic wastes right away from any risk of polluting either drinking water or fresh water streams. It relies for its safety upon the

huge dilution which is potentially available. Sometimes the waste is set in concrete before being taken to sea, and this means that toxic matter only enters sea water infinitely slowly. Given a suitable disposal point, it is difficult to imagine as safe a method of disposal short of absolute destruction.

70. Several firms specialise in taking toxic wastes to sea. The UKAEA has considerable experience in the disposal of some radioactive wastes to sea, though these are not our concern. The Authority's accumulated knowledge, however, could be very valuable. Some local authorities are also developing a sea disposal service for small quantities of very toxic wastes. Provided the discharge point of such wastes is outside territorial waters there is no need for any special authority to discharge, but in practice we understand that authorities offering a service consult the Ministry of Agriculture, Fisheries and Food. (See Chapter XX.)

71. In recent years there has been some international concern about possible pollution of the sea by plant nutrients from sewage and by poisons from industrial wastes. We have made no special study of this but, so far as solid wastes are concerned, provided the disposal point is chosen so that if and when containers perish dilution is vast, we think it would be difficult to show that the present and likely future scale of operation presents more than an infinitesimal hazard.

Chapter VIII—Present Organisation of Toxic Solid Waste Disposal

72. The organisation of industrial solid waste disposal has grown up, largely unplanned, over decades, and, as has been pointed out, is concentrated on disposal by tipping. This was clearly the only thing to do (at the time) with wastes from mining, the first industry to produce wastes on a very large scale. Moreover, it was impossible in those days to consider transporting the wastes more than a short distance, and in the main those industries, followed in due course by others, were able to acquire sites close to their works and just tip the waste on those sites. Hence the pit-hills or spoil heaps of, for instance, the coal mining and china clay industries which so disfigure the landscape in various parts of the country. These tips were privately owned by the industry producing the waste and became the customary method of disposal, and on the basis of sheer bulk still provide for the main proportion of solid industrial wastes. Often they receive only one kind of waste, which makes judgment on whether they present dangers or not much simpler to form.

73. This practice of tipping close to the place of production on land owned by the waste-producing firm became general for large waste producers even when the wastes were not inert. For instance, waste from coal mining (including overburden from opencast mining) may contain large amounts of iron pyrites which, on exposure to air or water, is converted into sulphuric acid and iron sulphate, which can be very polluting. Such wastes can also cause air pollution by sulphur compounds should a tip become ignited. Other tips of the mining industry give rise to drainage containing toxic metals such as copper, lead and zinc. Polluting drainage still takes place from tips of "alkali waste" deposited many decades ago. These are sometimes a considerable local nuisance, but are largely a legacy of the past. They have rarely polluted water needed for public supply partly because, in the chief industrial and mining areas, water authorities have obtained their water by impounding in the hills from which mining and industry, had it wished to go there, could have been excluded by the water authority buying the land.

74. Most of those tips adjacent to works, and which serve these works, were established before any Planning Acts became operative. It is believed that some new ones of this type could be controlled fairly well by the present planning legislation, because it is often well known what the waste is likely to be and the use of a tip can be limited to that by conditions attached to the planning consent.

75. Moreover, when the tip is close to (or, if not close to, owned by) the firm producing the waste, responsibility for pollution or nuisance, should it occur,

is more easily laid at the proper door. The firm must know that even when they have disposed of the waste they have not disposed of responsibility for the waste. This must make them more careful about what they deposit than they might otherwise be; they must bear in mind both Common Law and Section 21 of the Water Act 1945. This does not apply to Scotland, but there are similar if more limited inhibiting powers under non-statutory law and in some areas in byelaws.

76. By contrast with the waste-producing firms, which require land on which to tip the waste, there is the case of an owner or operator of an excavation who requires to fill it. It is believed that, in some areas, holes in the ground are being produced quicker than they can be filled—certainly they cannot be filled speedily unless house refuse can be used. This was the reason for the tests which have taken place since the war on the wet tipping of house refuse (Chapter XI). Many of the excavations—for instance sand and gravel pits—do contain water and are in contact with underground waters of the area. The risk of pollution from toxic or putrescible matter is therefore very obvious. Such tips are quite unsafe for toxic solid wastes—or even for any solid waste containing much soluble matter.

77. There are, of course, dry holes which need to be filled, and wet holes which are not in contact with aquifers, e.g. some clay pits. These are more likely to be used for toxic wastes and less likely to give serious trouble quickly, but they could give trouble due to displaced polluted water. The number of them available within easy reach of manufacturers with sufficient waste to justify their purchase must, however, be very small.

78. Table I indicates that the greater part of the total waste from the selected industries, and the greater part of the toxic waste too, is recorded as being discharged to tip as distinct from being disposed of through a local authority or a contractor. We assume that this means disposed of to a tip belonging to the firm which produces the waste, or a tip belonging to another firm, not being a disposal contractor, which wishes to fill an excavation. If we make the further reasonable assumption that a firm just wanting to fill a tip is not likely to take highly toxic waste, it would seem that most of this waste is disposed of on the producing firm's own tips. This is satisfactory in the sense that the producer of the waste is still responsible for it after disposal, and he may be expected to be reasonably cautious as to what he deposits on his tip. But it may be unsatisfactory because the tip site might not have been originally chosen with toxic wastes in mind. Moreover, a manufacturer may know little about water pollution, and less about the risk of it in his own particular area. We do not know how many of them may be living in what may, or may not, prove to be a fool's paradise.

79. There has been, of course, a parallel development in the domestic field. With increasing urbanisation and rising standards of living, solid wastes were produced in quantities which could not be burnt in the home or buried in the garden. These became the responsibility of the local authority, and in recent years the most common method of disposal has become controlled tipping. This has, we understand, proved technically satisfactory.

80. Like so many private tips the local authority tip is intended for one type of waste only, even if it is so heterogeneous and variable as house refuse. Also, it is usually owned and operated by the same authority which has the waste for disposal. It should therefore have been chosen with care, to avoid obvious dan-

gers of water pollution and nuisance, and operated according to best practice; the object is to do a job and not to make a profit. Experiment has shown the potentialities of house refuse for pollution; experience has shown that only on very rare occasions has it occurred in underground water. Water undertakers stress the first of these, disposal authorities the second. A state of watchfulness rather than harmony reigns, but it is a condition which makes for safe disposal of refuse. The number of cases of surface water pollution by house refuse is greater, but it is still relatively infrequent.

81. Local authorities generally over the years have not accepted industrial solid wastes in the same way as they have accepted industrial liquid wastes. The situation is exemplified by the common meanings of the term "trade" in the two connections. "Trade effluent" means the liquid wastes of industry; "trade refuse" means the solid waste of commerce, shops and markets. In many cases local authorities had to admit industrial effluents to the sewers if they wanted industry in their areas, because increasingly the only practical outlet for the liquid wastes of industry was to the sewers—nearby rivers being either non-existent or out of the question because of the Pollution Prevention Acts. There was no such pressure to deal with industrial solid wastes, largely because where they had to be transported others besides the local authority could do the transporting.

82. As firms became more crowded in cities, facilities for disposal of solid waste on or near the firms' own land became rarer, and since many firms were too small, or preferred not, to undertake disposal of solid wastes themselves (including both transport and tipping) there was clearly an opportunity for the growth of specialised firms whose main business is the carriage or disposal of both solid and liquid waste. For this purpose they have their own transport, and frequently their own tips, and they are able to operate at a profit. Most of these tips are in rural areas where the demand for land for industry, housing or amenity is small compared with the urban areas.

83. Most houses still unconnected to sewers are provided with either cesspools or septic tanks which must be emptied at intervals. For this purpose, tankers are needed. Sometimes these are provided by the local authority, sometimes by specialised firms. Whether or not the firms collecting and disposing of industrial solid wastes and those performing the same service for septic tank liquors were always identical, the inevitable tendency was for them to become so. The residues from domestic sewage were often spread on land, though now an increasing proportion is taken to a treatment works; but the solid waste required a site for tipping and in general this was privately owned.

84. These tips need to be distinguished from private tips belonging to firms producing the waste and local authority house refuse tips, because they receive a multiplicity of wastes of very different kinds, often imperfectly understood by the operator, and they are operated for profit, a fact which must result in a tendency for wastes to be accepted when they should not, just as water authorities have a tendency to object to wastes when they need not.

85. In recent years quite a number of firms have specialised in both the removal and disposal of unwanted, harmful materials; we have received evidence from no less than 18 of them. There appears to be no doubt that since the war most of them have both grown in size and have prospered, evidence of a growing demand

for their services and of increasing production or increasing difficulty of disposal (or both) of difficult wastes. There is no doubt that they are performing a very considerable service to industry, particularly to relatively small factories or firms with relatively small quantities of specific types of waste to dispose of. One cannot expect small firms to be experts in waste disposal; one need not be more surprised at their making use of specialised firms to take away their wastes than one is at their use of such firms to take their goods to market or to their customers.

86. Many of these contractors are responsible firms which have selected disposal points which are not objected to by such interests as river authorities and water undertakers. There has been a good deal of rationalisation in the industry in the past few years, and some of the firms are now large enough to employ professional staff—chemists to advise and carry out analyses. Such appointments in the main have been made since this Committee was formed and there is as yet no general fund of experience for them to draw upon.

87. Quote recently a trade association—The National Association of Waste Disposal Contractors—has been formed, with one of its aims the preparation of a code for practice for tip operation.

88. Advantageous though all this is, there are disadvantages in waste disposal by contractor. It has already been mentioned that, if the private tip of a manufacturing firm with particular types of waste causes pollution or any other nuisance, tracing the responsibility might not prove a very difficult job and damages could be claimed and a remedy sought from the firm causing the damage. But when a manufacturer pays a contracting firm to dispose of the waste he divests himself not only of the waste but also in all probability of the responsibility for safe disposal. This now devolves upon the contractor, who may not know sufficient about the waste to determine what constitutes safe disposal. He may ask, but the manufacturer may refuse information on the grounds that to divulge the analysis of the waste would be information valuable to a competitor. In that case the contractor could refuse to take a waste he was suspicious about, but the manufacturer could retort that there were other contractors not so particular who would be glad not only of that commission but to deal with the whole of the manufacturer's output of waste. Or he might offer a higher fee for disposal, maybe privately to the contractor's agent, or the suggestion might be made (or it might not need to be made) that a particular batch might be dumped somewhere unseen where its source could not possibly be traced.

89. Other possibilities may come to mind also, the total result being to suggest that, as things stand at present, the relationship between manufacturer and contractor (particularly if there are two contractors, one for transport and one for disposal) offers too many opportunities to those who are concerned to get rid of waste rather than to dispose of it safely. Evidence that such opportunities are taken is, of course, not easy to come by, and we make no specific accusation. There is no doubt that dumps of objectionable waste are sometimes found in quiet out-of-the-way places; we have been told in evidence that "too much" unauthorised tipping occurs even in areas where the county council has special powers of control (see Chapter IX); and that there have been instances of workmen in charge of tips being offered payment to accept loads without questioning them.

90. Although we have been led to raise the question of illicit tipping during consideration of the role of contracting firms in waste disposal, it must not be supposed that we lay the responsibility for all of it at their door, much less that it alters our view, already expressed, that contractors are rendering a considerable service to industry. We are only concerned at present with the fact that "fly" tipping does take place.

91. It goes almost without saying that tipping in an unauthorised spot is likely to be more dangerous than tipping on a site which has been authorised at least for some types of waste. It could well be that sometimes it would be safer in practice to accept a waste although it appeared a bit doubtful for the available tip than to refuse it knowing the probability was that it would only be put surreptitiously somewhere which was far less suitable. Whether it would be a right thing to do or not is another matter, but there is no point in ignoring the possibility of fly tipping and it becomes more and more likely if more and more difficulties are put in the way of "reasonably safe and proper disposal". This is not the only situation in life where, if one insists on absolute perfection, one ends up with something less perfect than one would otherwise do. And we are reminded of our terms of reference, which require us to consider not only legislation and control but facilities for disposing of toxic wastes.

Chapter IX—The Law Relating to Toxic Solid Wastes

92. In many of our discussions, and in much of the evidence we have received, comparisons and contrasts have been made between the situations as they exist for solid wastes and for liquid wastes respectively. The point of such comparisons is that the disposal of liquid toxic wastes to sewers and rivers is a problem which is adequately catered for in law and administration, and which has been technically studied over several decades. The situation is quite different, as we explained in Chapter I, in relation to solid wastes. A consideration of the difference between the two kinds of waste will show why, and we have to take full cognisance of these differences. But there are also important similarities, one of which is that a solid toxic waste has very often to become liquid (to dissolve in water) before it can cause pollution; if it did not do so it would never pollute. It is therefore instructive, and could be profitable, to approach some of the many facets of our problem by way of the corresponding features of the liquid-waste problem. This is the case with the legal aspect, which is dealt with in this way in this chapter.

ENGLAND AND WALES

Liquid Wastes

93. Under the Public Health Acts (the fundamental one is 1936) a local authority is responsible for the drainage of its district. It must provide sewers as necessary for both foul sewage and surface water drainage, and for the proper disposal of each. Most inland authorities have their own sewage treatment works, but some combine with other local authorities to provide and operate joint works under the control either of one of the authorities or of both or all the authorities jointly, or of a joint board consisting of representatives of each of such authorities. Under the Rivers (Prevention of Pollution) Acts 1951 and 1961, effluents from these works, when discharged to a stream, require the consent of the river authority, which can lay down conditions as to quality and quantity. Failure to observe such conditions could lead to prosecution. The river authority is required to be reasonable—at least, if the conditions are thought to be unreasonable the local authority can appeal to the Minister about them.

94. For many years before 1937 many local authorities permitted industrial firms to discharge trade effluents into their sewers, and these were then treated at the works and discharged to the river. Sometimes treatment was most inadequately done and, indeed, it is not going too far to say that adequate control was not achieved until after river boards (the predecessors of river authorities) were

set up under the River Boards Act 1948. Other local authorities would not accept industrial effluents* at all. Some accepted them without really knowing that they were doing so. But in 1937 the Public Health (Drainage of Trade Premises) Act gave industry—and local authorities—certain rights in the matter, and practice is now much more uniform. These rights had general application to liquid trade wastes, including, of course, liquid toxic wastes. There were certain classes of exempted effluents, but the most important of these were to a large extent brought under general control by Part V of the Public Health Act 1961.

95. Broadly speaking, a trader now has the right to serve notice on a local authority that he proposes to discharge an effluent of such-and-such a character to the sewers. The local authority may consent unconditionally, or may lay down conditions relating principally to quality, quantity and payment or, by implication, may refuse consent. If the trader is aggrieved by the ruling of the local authority, he may appeal to the Minister against it. The conditions a local authority may lay down may include limits of concentration for certain substances, including toxic substances, and this may necessitate pre-treatment of the effluent before discharge.

96. Traders value their rights and are, we think, concerned not to abuse them. They also acknowledge that since the services given by the local authority cost money they must be paid for and that, though they have rights, they cannot expect favours. The local authorities, on the other hand, have learnt to be restrictive only so far as it is necessary to be for the protection of their sewers and works, in the interests of efficiency of sewage purification, and so that they may satisfy the requirements of the river authority.

97. When the trader discharges his liquid effluents direct to the river he must deal direct with the river authority, just as must the local authority, and the 1951 and 1961 Rivers (Prevention of Pollution) Acts apply. The river authority too can, and where necessary does, require a toxic effluent to be detoxified.

98. Below the upper limit of tidal waters, river authorities (in the absence of a special Order under Section 6 of the 1951 Act) only have full authority over discharges which have started or become substantially different since the operation of the Clean Rivers (Estuaries and Tidal Waters) Act 1960. The seaward limit of those powers is precisely defined for each river in the Act itself, and beyond this the Rivers (Prevention of Pollution) Acts do not apply. We need not discuss these circumstances here.

99. If a discharge of, *inter alia*, toxic liquid waste is made not to the sewer or river but to an aquifer by well, borehole or pipe, the river authority's consent is also required under the Water Resources Act 1963, Section 72. Again, conditions may be laid down and again an appeal is provided for.

100. Any mode of disposal of liquid effluents not covered by statute law against pollution is not relevant to this section of the report.

101. Under all these arrangements there has grown up a body of knowledge and experience in the hands of specialist chemists, trade effluent inspectors, plant manufacturers and operators, and so on, who can provide, operate, oversee

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* Throughout this report this expression is to be regarded as synonymous with "trade effluent" as defined in the Public Health (Drainage of Trade Premises) Act 1937.

and inspect plants and processes, so that more and more the disposal of liquid toxic wastes has become safe and satisfactory. This is, of course, at a considerable expense; safety must be paid for. Whether this has increased the problem of disposal of solid wastes is a point we must return to in due course.

Solid wastes

102. Domestic solid waste is officially known as "house refuse", for which, however, there is no legal definition. It seems to be accepted that it is the sort of refuse which arises from the ordinary domestic occupation of a house, i.e. solid matter which is worthless to the occupier and which he wishes to cast aside. It can, therefore, have an even more diverse composition than sewage and, of course, the individual constituents of refuse do not mix like those of sewage.

103. The principal Act dealing with house refuse is the Public Health Act 1936. Under it (Section 72) a local authority may remove and dispose of house refuse and may even be required by the Minister to do so. The service must be free, i.e. it is a charge on the rates. A local authority is also given power to provide places for the deposit of refuse (tips), and plant for treating and disposing of it (disintegrators, incinerators, etc.) (Section 76).

104. In general, therefore, the duties of local authorities relating to house refuse are almost identical with those relating to domestic sewage—they must collect it and dispose of it as a community service.

105. There is no such similarity between a local authority's powers and duties relating to trade solid wastes and those relating to trade liquid wastes. They have no duties respecting trade refuse at all; they may undertake its removal and disposal, either generally or of specific types, but there is no provision for requiring them to do so (Section 73). If they do collect, they must make a charge. An exception to this is the Inner London Boroughs, who have a statutory duty to collect trade refuse on request (London Government Act 1963, Section 40 and 11th Schedule).

106. An even more important point of difference is in the general understanding of the meaning of the terms "trade refuse" and "trade wastes" or "trade effluents". Under the 1937 Act, trade premises are those used for carrying on any trade or industry, and trade effluents are liquids (not being domestic sewage) produced in the course of any trade or industry carried on at those premises. Since trade as ordinarily understood—the buying and selling of goods—is different from industry similarly understood—the manufacture and fabrication of goods—and since the mere activity of buying and selling produces no effluent at all except domestic sewage, trade effluents have, in practice, meant industrial effluents. The Act itself was passed with the well-understood intention of dealing with effluents from industry. It does, however, contain a provision under Section 7(2) by which a local authority may undertake to deal with substances produced in the course of treating any trade effluent on the premises.

107. Trade refuse, however, is not defined in general legislation. In disputes as to whether a particular solid waste is trade refuse, it has generally been accepted as meaning primarily shop and office refuse—the refuse of trade and commerce—and not industrial refuse—the solid waste from manufacture and processing—with part of which we are concerned. So that although the great majority of

local authorities say they collect trade refuse (see Refuse Storage and Collection, HMSO 1967, page 76), they do not mean that they collect industrial refuse, much less that they collect toxic solid wastes.

108. The Public Health (London) Act 1936 did give a definition of trade refuse; it was the refuse of any trade, manufacture or business or of any building materials (Section 304). This Act was, however, repealed in 1963, and the definition was not repeated in the Act which replaced it.

109. It is clear from all this that there is no such relationship between industry and local authorities respecting toxic solid wastes as there is under the 1937 Act in respect of liquid wastes. It will be one of our tasks to consider whether it would be profitable to establish such a relationship.

110. Nor is there a situation relating to direct disposal of industrial solid wastes similar to that relating to direct disposal of liquid wastes to rivers, streams or aquifers. There an industrialist needs the consent of the river authority, but he has the right to discharge within the terms of the consent. But for solid waste disposal, particularly by tipping, there is no authority corresponding to the river authority which can deal with the matter. Some of the provisions of the Public Health Act 1936 and the Planning Acts are, however, relevant.

111. Under the Public Health Act 1936 (Sections 91–100), local authorities are empowered to take action to secure the abatement of "statutory nuisances". Among the definitions of the statutory nuisance is "any accumulation or disposal which is prejudicial to health or a nuisance", which might well cover a tip in which toxic wastes have been disposed of dangerously. But presumably a nuisance must exist before it can be abated, and it is not a good way of controlling dangerous situations merely to wait until they have actually come about and then compelling them to be rectified. In this connection the short Public Health (Recurring Nuisances) Act 1969 must be referred to. This Act which is to be construed as one with Part III of the Public Health Act 1936, gives power to local authorities to deal with statutory nuisances which have abated but which are likely to recur on the same premises.

112. Before a tip is established or extended the Planning Acts must be satisfied; broadly speaking, establishment or extension involves a material change in the use of the land in question, and planning permission must be obtained. This is a matter for the local planning authority or the Minister on appeal. The authority requires a statement in which information is given as to the nature of the substances to be tipped, and at this stage potentially interested bodies, including local water undertakers and river authorities, may make representations of which the planning authority takes due note. Planning permission may be refused on account of the possible toxic effects of the refuse (on underground water or in other ways); or conditions relating to the types of material tipped and the way in which and the height to which tipping takes place may be attached to a consent in an attempt to preserve amenity and to prevent materials being tipped dangerously.

113. In general terms the Planning Acts deal with a project (e.g. a tip) before it becomes established and the Public Health Acts operate after experience has shown it to cause a nuisance. The actual operation of the tip, including the nature and amount of the materials to be tipped, is subject to no legislative

control except with regard to such matters as can be included in the planning consents. In our view the disposal of toxic solid waste, by tipping or in other ways, is a highly specialised subject not suitable for detailed control under the Planning Acts. There is also need for operational control after planning consents have been given, and it is unsatisfactory for this to be unavailable until a nuisance has actually been caused. It would be more effective to have a single authority, analogous to a river authority in the case of liquid effluents, which is responsible for the original permission to tip and the conditions attached to it, the day-to-day checking that the conditions are conformed with, the routine determination of the effect of tipping and, if necessary, the revision of conditions of consent in the light of experience.

114. It is also necessary to mention here Section 21 of the Water Act 1945, which provides that "if a person is guilty of any act or neglect whereby any spring, well or adit, the water from which is used or is likely to be used for human consumption, is polluted or likely to be polluted he shall be guilty of an offence against this Act". The importance of this provision is that it is not necessary to wait for the pollution to occur before being able to take action in the Courts. There is an offence if pollution is only likely to occur. Nor need it be water used for human consumption which is contaminated, only water likely to be. There might, of course, be difficulty with the meaning of the word "likely", and we have never heard of Court action actually being taken, but the Section has been much quoted as a warning.

Common law

115. In the absence of a complete code of statute law it becomes necessary to consider common law. Indeed, this would be necessary even if we were primarily concerned with liquid effluents, for which a complete code of statute law exists, because the common law relating to pollution has been invoked successfully many times since World War II. It is, however, well known, and there is no need to describe it here. Common law as applicable to toxic solid wastes, however, is not so widely appreciated, and it is right that it should have a brief mention.

116. It is considered that trespass is unlikely to arise in practice, and our consideration may therefore be limited to nuisance and negligence. Nuisance may be defined as unlawful interference with a person's use or enjoyment of land or of some right in connection with it. The possible forms of interference are innumerable, but some of the most usual are noise, smell, vibration and the pollution of air and water. Most of these could arise from the disposal of toxic wastes by tipping, and could damage property or interfere with personal comfort. It does not, however, follow that *any* harm constitutes an actionable nuisance—the whole law on the subject represents a balance of conflicting interests.

117. Negligence may be defined as a breach of a legal duty to take care resulting in damage to property or injury to persons. Of particular importance in relation to toxic wastes is what may be called the principle of Rylands *v* Fletcher, namely, that a person who, for his own purpose, brings and keeps upon his land something which is likely to do damage if it escapes, keeps it at his peril, and if he fails to do so he is, even without proof of negligence, answerable for all damage which is the natural consequence of its escape. It is easy to see how this could apply to a toxic waste placed on a tip, escaping from it in solution in water percolating through, and poisoning a water supply some distance away.

118. In theory, common law may appear adequate and sufficiently powerful. In practice, the history of water pollution has shown how necessary it has been to cover the disposal of liquid wastes by statute law, which creates statutory offences, awards statutory rights, sets up statutory organisations, and lays down statutory duties. We expect the same to be true in relation to solid toxic waste disposal.

119. It should be emphasised that all the laws we have been discussing have been those relating to the disposal of waste products whether toxic or not. There are no laws specifically and solely concerned with solid or liquid toxic wastes; nor, we think, could there readily be because of the difficulty, perhaps impossibility, of defining toxic wastes. Should we find the legal provisions regarding waste disposal to be inadequate because they do not deal fully with the problem of toxicity in those wastes, then we would have to recommend changes in the law regarding wastes generally, or some class of wastes which can be defined, e.g. industrial wastes. And we would have to have regard to the effect of our recommendations upon the disposal of wastes in that class which are not toxic. For instance, it might well be that some wastes ought not to be disposed of in certain tips without a certificate of analysis; but to require a provision in the law to secure this would necessitate certificates of analysis in the many other cases, of much wider occurrence and of much greater volume, where they would be quite unnecessary and would represent so much wasted effort. In such an event we would probably have to think of some other method of achieving the same end.

SCOTLAND

120. Under existing legislation, drainage in Scotland is subject to provisions similar to those in England and Wales with the important exception in the context of our considerations that there is no general right of connection to sewers for trade effluents such as that conferred by the Drainage of Trade Premises Act 1937; this Act does not apply to Scotland. The legislative provisions on drainage are contained mainly in the Public Health (Scotland) Act 1897, and the Burgh Police (Scotland) Act 1892. Power to control pollution of rivers, inland waters and certain estuaries and coastal waters is contained in the Rivers (Prevention of Pollution) (Scotland) Acts 1951 and 1965. This power is in substantially the same form as in England and Wales, but it is exercised by river purification authorities with the specific function of preventing pollution. These authorities do not have power to control abstractions from streams or underground sources unless an order to control the abstraction of water for the purpose of spray irrigation has been made. To date no such order has been made. An exception in their powers which could have a bearing on our interests is that no control is exercisable over discharges to boreholes unless potable water is liable to be polluted, when the provision of the Water (Scotland) Act 1946 can be invoked by local water authorities.

121. The Sewerage (Scotland) Act 1968, when it comes into operation, will require local authorities to provide such services and sewage treatment works as may be necessary for draining their areas of domestic sewage, surface water and trade effluents. Where practicable at a reasonable cost, local authorities will also be required to take sewers to points where owners of premises can connect their drains at reasonable cost to themselves. Occupiers of trade premises will have a

general right to discharge trade effluents to local authority sewers, subject in the case of new discharges to the consent of the local authority. Local authorities will be able to make charges and impose conditions in giving consents, subject to appeal to the Secretary of State for Scotland. Existing discharges are permitted to continue subject to conditions laid down by the local authorities or the Secretary of State on appeal. The Act will repeal most of the earlier statutory provisions in the Public Health (Scotland) Act 1897 and the Burgh Police (Scotland) Act 1892.

122. Collection and disposal of solid refuse is undertaken by the local authorities, who normally do not put any of this work to contract. The cities and the larger towns have taken local act powers to collect trade refuse. These powers authorise the making of arrangements for the collection, removal and disposal of trade waste at such times and on such terms and conditions as the local authorities may determine. The interpretation placed on trade waste generally excludes industrial wastes, but one instance was drawn to our attention where industrial waste is accepted for disposal on a tip. Other municipal local authorities collect refuse under the Cleansing Provisions of the Burgh Police (Scotland) Act 1892, which vests certain forms of refuse in them to sell or dispose of as they see fit. Certain industrial wastes are specifically excluded from these provisions, such as wastes from "breweries, tan works, soap or chemical or other works". County local authorities are enabled by the Local Government (Scotland) Act 1947 to set up Special Districts in landward areas to make arrangements to remove refuse from roads and houses. In short, we see a position in which collection and disposal of trade waste is at the discretion of local authorities even where they have specific power to deal with it, and trade waste is rarely considered to include industrial waste.

Local Acts

123. A number of Local Acts have sanctions relating to the tipping of wastes, the effect of which is the exercise of greater but not absolute control over what is tipped. They may be illustrated by the Hertfordshire County Council Act of 1935 as modified by that of 1960.

124. Section 26 of the 1935 Act makes it unlawful for any authority, body or person to form or add to a deposit of refuse which has been imported into a local authority's area within the county without the consent of both the county council and the local authority concerned. This was presumably an acknowledgement that refuse collected and deposited within the area of a single local authority was entirely an internal concern of that authority and no business of the county council. This requirement has now gone by virtue of Section 102 of the Local Act of 1960. The county council now has the same responsibilities over refuse wherever it is deposited within the county.

125. The provisos are more technical and still stand, with only slight amendments. They attempt to deal to a limited extent with the situation caused by the absence of a very precise definition of the term "refuse" by stating certain things which it is not. For instance, it is not manure deposited on land for agricultural purposes, it is not spoil produced in the construction of roadways, nor dredgings from rivers and canals, nor waterworks sludge deposited on sites previously used for the purpose, and so on.

126. For all other types of refuse, application must be made to the county council and local authority before it can be disposed of by tipping, and the councils may consent, unconditionally or subject to conditions, or refuse the application. In the event of an applicant being aggrieved by a refusal or the conditions, he may appeal to the Minister. The similarity between these provisions and the general legislation relating to liquid waste (though that was passed later) will be apparent, and it calls for consideration later.

127. Of course, the above provisos do not nearly cover the types of waste which can be tipped with only elementary and commonsense precautions, covering consolidation, nuisance, fire, unsightliness, and so on. For such wastes which are also inert, the county council prepared "Standard Conditions" which are normally attached to consents. In the same way there are Standard Conditions covering putrescible wastes, such as domestic refuse, organic material and the like. These require more care to be taken to prevent nuisance, and a requirement is often included that the floor of the tip shall first be covered to a prescribed depth with reject material or other agreed covering. In both sets of conditions a clause prohibits deposits of poisonous material likely to cause pollution.

128. It should be added that tipping without consent or infringement of any condition is an offence liable to penalties of which the maximum (£200 plus £50 per day) must have been regarded in 1935 as most substantial.

Chapter X—The Travel of Pollution from Tip to Aquifer or River

129. It has been pointed out earlier that most industrial solid waste, including toxic waste, is tipped, and concluded that, come what may, much of it will have to be tipped for many years to come. It is necessary, therefore, to answer the question "Where and with what precautions can the tipping of toxic waste be done so that water pollution is prevented?". At the moment this is largely a matter of judgment, even of "hunch", which is hardly good enough for a scientific age. No doubt on certain aspects judgment must continue to be exercised, but it can be made much more informed and reliable by a thorough understanding of the processes concerned, and more precise insofar as any of the processes can be expressed in quantitative, or even semi-quantitative terms. This chapter explores the possibilities of doing this.

130. When a toxic solid waste is disposed of on a dry tip and covered it is beyond the reach of the ordinary senses, and usually undetectable even by specialist instruments unless borings are made. In the normal course of events, and short of excavation, the next time, if ever, it becomes detectable is when it emerges in the water of a spring, having travelled downwards to an impermeable layer and then on the top of the layer until the outcrop is reached, or when it contaminates water in an aquifer which is pumped up for supply or other purpose. What happens in the interval? How quickly? And can it be foretold? These are obviously vital questions.

131. It will be profitable to divide what happens into distinct processes, as follows:

1. It must rain, and the rainfall must exceed evaporation, so that the liquid percolates to the waste.
2. Toxic matter must dissolve in the percolating water; without solution it is unlikely to move.
3. If the waste has been tipped on an existing tip the solution must percolate through that to its base.
4. Further downward percolation with perhaps a degree of lateral diffusion occurs until the water table is reached.
5. The solution then travels with the water in the aquifer, mixing with it more or less quickly as it does so.
6. The contaminated water is then pumped to the surface together with other water flowing in from other directions within the influence of the cone of depression of the well or borehole, at a total rate depending on what is needed and the maximum yield of the borehole or well.

7. If, at any of these stages, the water reaches an impermeable layer, it must travel over it, and its subsequent history will be changed. The processes will each be considered in turn.

1. Rainfall and percolation to toxic material

132. There would be no pollution due to solid toxic waste tipped dry were it not for rain. Moreover, there would be no pollution by mere showers that quickly dry up without penetrating the soil. Neither would there be any pollution by rainfall taken up by growing plants before it had percolated sufficiently far to reach the toxic waste. The water reaching the waste should, in fact, be no more than the rainfall minus the evapotranspiration for the area. In practice it might be rather larger than this, because there might be no plants growing vertically above the toxic waste and the amount of water lost in the summer time by capillary attraction and evaporation might be less than would have been lost by evapotranspiration. But this difference would not be very large.

133. In the south and east of England the annual rainfall may not greatly exceed 20 inches, and the evapotranspiration might not be much below that figure, so that annual percolation might be only a few inches. In the west and north it could be 20 inches or more. The important point at the moment is not the difference between these figures, but that they are both fairly small and represent a very slow average rate of percolation. Water would reach the waste at a rate almost infinitesimal compared with that at which it would reach waste tipped into water. It will have been noted that, generally, where we have spoken about tipping we have both meant and stated dry tipping. We do not think that tipping into water can be a satisfactory method of disposing of toxic wastes except in very special circumstances.

134. If the tip itself, the toxic wastes in it, and the surrounding land are all sufficiently permeable, then rainfall should percolate vertically downwards and each small area, including the surface of the toxic waste, should receive its fair share. It is easy to see how such a regime could be changed so that the toxic waste could receive much more or much less than its fair share, and this could make all the difference between safe and unsafe disposal. If the toxic and any other waste, or the whole tip and the surrounding area, are so disposed that natural drainage or percolation is towards the toxic waste, then clearly, toxic matter could be leached out many times more quickly, and what might have been safe disposal could be most dangerous. Safe and unsafe disposal could depend upon tip management as much as on any other factor.

135. Conversely, it adds to safety if the toxic waste is so disposed as to receive less than its fair share of percolation. In some cases this could be done by taking advantage of the topography of the area. In most cases it could be promoted by tipping the toxic waste in deep rather than shallow layers, so that the area exposed to the percolating water is small, or more direct and effective action could be taken where necessary. We have frequently received the comment about a tip that it presents no risk to ground water because there is an impermeable layer between that and the tip. This certainly interrupts the chain of events we are considering. But would it not be an even more effective interruption if the impermeable layer were above rather than below the toxic waste? If you want to keep dry, the proper place for an umbrella is over your head rather than under

your feet, and to keep percolating water from reaching the toxic waste at all is surely, in theory at least, a more certain way of preventing toxicity from being leached out and carried to ground water than allowing it to be leached out and then trying to prevent it reaching the ground water. Once it has been leached out it must go somewhere. We would be very glad to see the economics of some such procedure worked out, and if they were favourable it might be deliberately tried out under conditions where observations could readily be made.

2. Toxic material entering solution

136. The first point to note here is that the concentration of toxic material going into solution is limited by solubility. The total amount of toxic matter leaving the tip is limited to the volume of water gaining access to it multiplied by the solubility of its toxic content. But it may be less than this depending upon whether saturation is reached. There are various ways of discouraging solution which could be adopted. One is effective consolidation of the toxic waste, which could reduce the amount of water which would come into intimate contact with the waste during its descent. Or the waste could be mixed with, for instance, clay or even wet or semi-dried sludge, which would reduce its porosity. In extreme cases the waste could be set in concrete.

137. At the other extreme, the very worst thing to do would be to spread the toxic waste over a wide area and make it permeable by mixing it with other and more permeable waste. Unless the waste is oxidisable biologically it is far better from the pollution angle to dispose of it as a concentrated solid block than loose and mixed with hundreds of times its volume of sand. But on the other hand, if it *is* oxidisable biologically, spreading it in a thin layer on the surface may be the best way of securing its destruction.

3. Percolation through the tip

138. Little need be said about this, but it is worth mentioning that if the toxic waste is tipped on the top of other waste matter the descending percolate must pass through material which could affect its composition, either directly or by providing an opportunity for biological destruction. Whether this would be useful or not would depend upon the nature of the toxic matter, but if the tip operator knew this, as he should, he could do a great deal to provide opportunity for biologically unstable substances to break down before they entered the ground proper. Again, tip management could be an important factor in securing safe disposal.

4. Percolation to the water table

139. It is at this point where the percolate enters the ground proper that local geology becomes important. The vertical distance to the water table may be anything from a few to hundreds of feet, and the intervening rock, assumed permeable for the purposes of this section, may be compact, or highly fissured, or composed of any of a number of materials such as sand, gravel, chalk and limestone. All these factors affect the time of travel and the opportunity for adsorption or destruction of toxic matter. If the type, shape, size and size distribution of the grains composing the rock is known, it may be possible to calculate roughly the speed at which the percolate descends.

140. As far as "ordinary" pollution is concerned—i.e. bacterial pollution of ground water—the presence or absence of fissures is the most important matter. In their presence percolate may reach the water table a few minutes after leaving ground level, and thereafter travel along the aquifer at anything up to a few miles per day. Such rapid and uninterrupted travel gives little opportunity either for die-off of bacteria or for oxidation of organic impurity, but fortunately occurs only rarely. Sites for tips for house refuse are usually objected to if fissures are likely to exist.

141. In the absence of fissures, however, the percolate must meander slowly through a maze of voids and small capillaries in permeable rock in which there should be ample opportunity for biological destruction, and removal of intestinal bacteria to take place, and they constitute a most effective mechanical filter as well. Hence, pollution of groundwater with compounds or organisms from sewage and sewage sludge, from manure and farm waste, or from refuse deposited on the surface of the land is, under these conditions, only of the rarest occurrence.

142. If the percolating water contains toxic matter, that must travel equally slowly, or possibly more slowly. If it is biologically oxidisable it will gradually be oxidised. Or some of it may be adsorbed on to surfaces, particularly surfaces of clay particles. But this is not certain, and the long descent of the percolate through non-fissured rock to the water table is not the reliable barrier to toxic materials it is to bacteria and natural organic matter. It must delay pollution of the groundwater, but it might do little more than that. It would clearly help in assessing the situation to know whether the toxic matter was, in fact, oxidisable or not, which constitutes a further reason why a tip operator should know what he is dealing with.

5. Movement of water in the aquifer under hydraulic gradient

143. When the percolate has joined the standing water in the aquifer it must move with that water under the influence of gravity at a velocity which will depend upon the porosity, the hydraulic conductivity and the hydraulic gradient. In many formations in the United Kingdom ground water velocity is of the order of a few inches to a few feet per day, and it would be calculable if conditions underground were known precisely, but they never are. On reasonable assumptions calculations can be made which are probably not very wide of the mark. The toxic matter in the water will certainly not travel any quicker than the water itself, but it might well travel more slowly on account of adsorption or ion exchange or "chromatographical" separation. One of the most difficult questions to answer is whether, in a given case, water which has percolated through a tip has reached a particular borehole having been purified on the way, whether it has reached the borehole but its content of impurity merely held back on the way (temporarily or permanently) or whether it will never reach the borehole.

144. We are indebted to the Water Research Association for working out for us by computer a hypothetical example put to them with simplifying assumptions. These assumptions concerned the pumping rate from a borehole, the size of the tip, the distance of the tip "upstream" of the borehole, and its distance from the centre line of flow, the porosity, hydraulic conductivity and hydraulic gradient. It was also assumed that the amount of percolation was 4 inches per

annum, and that the toxic matter in the tip would just dissolve in one year's percolate. The time required for the percolate to descend *to* the water table was ignored; so was possible hold up of toxic matter by adsorption or other mechanism.

145. It is not justifiable to give here the results of such a hypothetical calculation in detail. It did, however, give certain indications, which we believe will be helpful.

146. On the assumptions that the effective porosity of the underground is 0·1, the conductivity per unit hydraulic gradient 0·06 ft. per second, and the natural hydraulic gradient 0·002, the time of travel from a water table directly beneath the tip to a borehole from ¼ to 1 mile away worked out at months rather than days or years. We do not think it would be right to attempt to be more precise than this, even were the assumptions known to be correct for the site in question. Nevertheless, where the circumstances are believed to be such that the above assumptions are justified, it is considered reasonable to conclude that if a tip has not contaminated a well or borehole over a period of years, then it probably never will. But such reasoning can never lead to absolute certainty even if the geology of the area is well known.

147. No allowance was made in the calculation for diffusion of the percolate in any direction. In the particular circumstances of the case that would have made little difference, most of the dilution of the waste being afforded anyhow at the pumping station itself, as described below. It might be as well to ignore diffusion, which is believed by some to be very small; if this is so, however, it follows that in most cases either the whole of the percolate from a given tip will reach a particular source or none of it will, and if all of it does then none will go elsewhere. It may be useful at times to bear this in mind.

148. In order to secure the maximum dilution of the percolate before it was pumped up at the hypothetical borehole, it was necessary to tip the hypothetical toxic waste over as wide an area as possible along the line of travel of the underground water. This appears to conflict with what has been concluded earlier, that the safest way of tipping would be in as concentrated a form as possible. The reason for the apparent contradiction lies in the basic assumptions made. In the present calculation it was assumed that, no matter how tipped, the waste would just dissolve in one year's percolate. Normally this would not be true, and dilution of toxic material with the underground water would best be achieved by reducing the volume of saturated percolate, i.e. by reducing the size of the tip. But in certain circumstances, spreading the toxic waste over a wide area might be more effective. Again, we conclude that disposal could be made safer by knowledge of the properties of the material and by skilled and knowledgeable tip operation.

6. Pumping to the surface

149. Little need be said about this except that it is here that the most certain process of dilution takes place. If all the percolate reaches the water source in a given time its concentration in the output is inversely proportional to the amount pumped from it. It is worth repeating the point that the greater the extraction from the source the less risk there is of a contaminant reaching a concentration which could be harmful. Conversely, with a small extraction from

a source there would be less risk of pollution getting there (more chance of it passing by), though if it did get there it would be more concentrated. These generalisations do not apply to small extractions quite close to large tips.

7. Impervious layers

150. An impermeable layer may be reached at any time after the percolate has reached the base of the tip. If it is reached at all it is most commonly reached at the base of the tip, this having been established on impermeable ground. At this point the percolate from the toxic waste will be joined by percolate from other parts of the tip (if any) higher up the hydraulic gradient, and by any water flowing out of the ground upstream of the tip and passing beneath it, but often this is culverted and it is desirable that it should be. The percolate, diluted or not, will then continue to flow over the impermeable layer, becoming more diluted with inert percolate (if any) on the way and by surface drainage after that, until either a stream is reached or the impermeability ends. Opportunities for dilution and oxidation before a stream is reached are usually quite limited, as can readily be seen, and this is probably the main reason why detectable pollution of streams occurs more frequently than pollution of underground water sources.

151. It is possible to study all the above processes in more detail, both in the field and in the laboratory, and this has been done to some extent with tipped house refuse. We believe that such studies in connection with the tipping of toxic wastes would be well worth while (See Chapter XII).

Chapter XI—Percolation from House Refuse

152. This report is not concerned with house refuse, but since tipped house refuse can result in a polluting percolate the behaviour of which in the ground must bear some relationship to that from other tipped waste, it may be useful to summarise what is known about possible pollution from house refuse. The most thorough controlled investigations were carried out by the staff of the Laboratory of the Government Chemist, and the results were published in 1961 together with detailed analyses and comment by a committee of the Ministry.* No claim was made that house refuse tipped elsewhere would give precisely the same results, but it was believed justifiable to take the tipping of up to 100 tons of refuse in each of a series of old sewage tanks, some 6 ft. deep, to be a reasonable simulation of what would happen in a large scale tip.

153. We are not concerned here with the experiments on refuse tipped into water. They showed clearly enough that the water became heavily and offensively polluted, and there is no doubt that this would be true of toxic wastes similarly tipped. When tipped dry, however, the refuse gave no percolate for several weeks—it absorbed such rainfall as did not evaporate. Thereafter, on a yearly basis, it gave an amount of percolate somewhat greater (about 4 in. per annum greater) than the rainfall less the expected annual evapotranspiration for the area. This did not seem unreasonable, because the vegetation on the tip surface was probably not as active in transpiration as vegetation on normal ground. It would not be unreasonable to assume that in the driest parts of the country the percolate from refuse (and probably from other tipped wastes) would not be more than double the average percolation for the area, and that in the wetter parts it would not be much greater than the normal percolation, expressed as a percentage.

154. This information itself could be useful. In the south-east of England, for instance, the natural percolation would often not be more than 4 in. per annum, or 90,000 gallons per acre per annum, and that from an acre tip certainly not more than 180,000 gallons per annum or, on average, 500 gallons per day. Assuming that from a borehole at risk from such a tip a million gallons per day was pumped then, on the average, the dilution of the percolate would be at least 2,000 times. Together with a knowledge of the character of the waste such a figure would probably give a good idea of what the effect on the borehole water would be, ignoring any purification en route. Of course, there is no way of

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* Pollution of Water by Tipped Refuse, HMSO 1961.

proving that this average dilution would occur all the time, but neither is there any reason to suppose that percolation from the tip would be seriously out of step with percolation from surrounding land.

155. During the first year of percolation, the quality of the percolate was highly polluting, being some 20–30 times as strong as settled sewage. This fact has no necessary relationship to percolation from a tip of toxic waste, but it does prompt the questions "If such a highly polluting liquid drains generally from the hundreds or thousands of house refuse tips in this country, and yet pollution of underground water only very rarely occurs, is it not plain that the purification capacity of the ground must generally be very large? Would not this purification capacity be available for toxic waste percolates also, provided, of course, that these wastes can be purified by the same means?" Assuming this to be so, it clearly becomes important to know if a specific toxic solid waste responds to the physical and biological purification processes that the ground offers.

156. Experiments were carried out on the effect on the percolates from house refuse of passing them through graded gravel and sand at rates approximating to those which commonly occur underground, e.g. about 1 ft. per day. It was found that there was a good deal of breakdown (60–80%) of organic matter, chiefly by anaerobic processes, in as little as 24 ft. of travel, with no sign that the process had gone as far as it would. This gives a clue as to the sort of experiments with specific toxic wastes which it might be valuable to conduct.

157. Generally, these experiments confirmed the safety of house refuse tipping at permeable sites when fissuring of the rock was unlikely, but showed that pollution could occur when heavy fissuring was present, making rapid travel of percolate from tip to water source possible. The report went on to discuss how such fissured areas could nevertheless be made safe for refuse tips, and we shall have occasion to refer to such matters in relation to toxic waste tips later.

158. Since that time chemists at some water undertakings have been examining records of refuse tipping in their areas and analyses of water from nearby wells and boreholes to ascertain if any changes in water quality (particularly changes of bacterial and organic pollution) could be related in time to the tipping of house refuse in the vicinity. Their findings, published in a series of papers in their journal,* were generally negative. Unfortunately, in no case was it possible to show beyond doubt whether these negative results were due to no refuse percolate having in fact reached the boreholes or wells, or to purification having been completed before it arrived there. But so many cases were examined that it is felt that in at least some of them the percolate must, in fact, have reached the sources so that it must have been purified on the way.

159. This is generally in accord with experimental results. It is also in line with the position regarding toxic industrial wastes. In both cases there is a high potential for pollution; in both cases the number of occasions it occurs is surprisingly small; but the cases of refuse giving trouble are often rarer than those involving toxic wastes because refuse percolates are amenable to biological purification, whereas percolates from toxic wastes sometimes are not. Another similarity we have not previously mentioned is that pollution of streams from refuse tips is more frequent than pollution of underground water, as is the case with toxic solid wastes.

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* J. Society for Water Treatment and Examination (1969 **18 Part 1**).

Chapter XII—Operation of Tips Receiving Toxic Wastes to Reduce Pollution from Them

160. It will be obvious from what has been said in the two preceding chapters that once a polluting percolate has entered the ground there is nothing that can be done artificially to stop its natural travel to, and then with, the underground water short of somehow intercepting it and piping it elsewhere. This may have to be done sometimes, but could not be contemplated as anything but a very expensive procedure, for its cost would undoubtedly far outweigh the extra cost of disposing of the wastes responsible for the percolate in a far safer manner, e.g. in the deep sea. It will be equally obvious that something could be done in tip operation to increase or reduce the amount of percolate and its strength. Wastes could be so tipped as to be much safer, or much more dangerous, than average, and some suggested procedures promoting safety will be considered in this chapter. They are described as "suggested" procedures solely because none of them has in fact been proved by strict scientific experiment to be effective, though we have no doubt ourselves on that score. What we cannot say precisely is how effective most of them would be. There is also uncertainty about how practical and how costly some of them would be; some might not be practical or worth the cost in particular cases; but they are mentioned as worth considering, and one or other of them might easily make all the difference between safe tipping and quite dangerous tipping. The responsibility of the tip operator is great.

1. Good consolidation

161. It does not require a high permeability to permit a few inches of rain to percolate through a layer of tipped waste each year but it does require some, and good consolidation of the tip must tend to reduce it. In some circumstances it could make the interstices so small that they are readily blocked by solid particles in the percolating liquid, and thereafter percolation might be quite negligible. It is impossible to say how much good the use of heavy vehicles, for instance, for consolidation would do but much artificial consolidation will usually be practised, and if the areas receiving the most toxic waste are given special attention it would represent good operation.

2. Other methods of discouraging percolation

162. The procedure just described makes percolation through the waste more difficult. An alternative procedure makes percolation through other and non-toxic waste nearby easier and thus achieves the same end. For instance, if a batch of toxic waste is surrounded on all sides by particularly permeable waste, e.g. builders' rubble, or even specially tipped gravel, percolation will take place

preferentially through that material and less will pass through the toxic waste. Thus, the rate at which toxic matter will reach underground water will be much reduced and disposal will present much less risk.

163. Again, if a batch of toxic waste is tipped as a deep layer instead of a shallow one, the surface area exposed to descending percolate and the amount of percolate reaching the waste will be reduced and this, too, will lessen the risk to underground water.

164. Other methods of tip operation, calling for no great expense but reducing threats to water, may present themselves at particular tips. The tip operator himself can contribute (or, of course, neglect to contribute) a great deal to safety.

165. Such methods, however, only reduce the rate of solution of toxic materials; they reduce the risk but lengthen the time over which it exists. Sometimes it may not even be desirable to adopt them, as for instance in the case of a toxic waste which is readily broken down in dilute solution. Then it may be better to spread the waste widely in thin layers so as to expose it as much as possible to biological action.

3. Methods of preventing pollution reaching a water source

166. The complete prevention of percolate reaching the groundwater will involve expense, and it must be determined locally how great the cost would be and whether it would be justified in any particular case. The most obvious method is to put a layer of clay or some other impervious material between the tip and the water at risk. Sometimes the clay is present as a natural barrier between the surface and the underground water, and many tips have been located on precisely such sites in order that the water below should be safe. This is good, but most of these natural clay layers have sufficient of a gradient to permit the percolate to flow over their surfaces and eventually reach streams, where it may or may not cause pollution depending on the material tipped, distance travelled and time taken. To be quite safe, such a clay layer ought to be saucer-shaped, so that all the toxic waste tipped is within the saucer. When the saucer is filled with percolate, further percolating water should overflow the edge of the saucer without passing through the toxic waste. The saucer would remain indefinitely filled with toxic percolate, and it would require an earthquake or an artificial boring to release it.

167. In at least one case the base of a chalk quarry has been made waterproof and the gradient arranged so that all the percolate reaching this impervious layer travels to one spot, from which it is discharged to sewers. The tip concerned was a house refuse tip, but the same arrangements could be as effective for toxic wastes if it was thought that the drainage could be dealt with at the local sewage works.

168. It may also be worth considering the possibility of covering the waste after tipping with clay or other impermeable material. If the clay cover could be made in the shape of an umbrella which extended beyond the limits of the toxic waste, then percolate would be kept from it indefinitely and none would reach the groundwater by descending through the aquifer; nor would percolate reaching rivers after flowing over the clay be contaminated with toxic waste. A disadvantage would be that the clay could not be placed in position until the waste had

been tipped, and if this took a long time some damage could be done before the protection could be applied. This is a matter which a rough calculation, taking into account rainfall, rate of tipping and absorption capacity of waste as tipped, would help to resolve.

169. So far, in considering tips we have had in mind holes or depressions, nearly all artificial, in the ground, which need filling. We have not considered tips above the surrounding ground level because spoil heaps which disfigure landscapes in some of our mining areas have now become, for good reasons, unpopular. But a tip entirely above the surrounding ground could be made so safe in relation to water supplies and rivers that we think the establishment of a few of them for the reception of toxic solid wastes (no doubt mixed with other wastes both difficult and easy to dispose of) should be closely considered.

170. We base our suggestions partly on theoretical grounds and partly on what we are informed is happening at a few places on the Continent. There, tipping is taking place above ground level to a height of up to 100 ft. The sides of these tips are being specially treated so as quickly to become clothed with grass and later with bushes and so on, and the tops of them will also eventually be reclaimed for "nature" or agriculture. It is hoped that the refuse involved will, after consolidation, be impermeable, but it seems to us that in many cases the sides and top coverings of such tips could well include a layer of clay or other permanently waterproof material. In these circumstances practically no water could enter the tip from rain and, the tip being above ground, none could enter it either from the sides or from below, and thus no water would drain from the tip. Water pollution just could not occur. Furthermore, because the tip does not become saturated it should never slip. Again, because of its situation the tip would never be forgotten, and there should be no risk of its being excavated accidently in ignorance of what it contains. Such a risk seems to us always possible where the contours of a tip are finally blended with those of the surrounding land, however desirable that may be on other grounds. The disadvantage of above-ground tipping is that the tip will always be seen, and if it were always to look like a tip this would be wrong. But being clothed with vegetation its outline could be made either to harmonize with its surroundings or in some cases to provide a not unattractive contrast. An isolated hill with vegetation growing on it is surely not unattractive in an otherwise perfectly flat landscape.

171. An even more positive method of preventing solution of toxic constituents would be to set the waste in concrete. This might be justified in cases of extreme toxicity which could not be destroyed by any practicable method, but it would be very expensive and if the character of the waste justified that expense it seems likely that it would also justify the expense of taking the concrete out to sea and sinking it in very deep water rather than retaining it indefinitely within a tip.

4. Use of tips of proved safety

172. Mention has been made of the impossibility of being sure in advance beyond any shadow of doubt that a particular waste on a particular tip will not have an adverse effect upon underground water. But one can be a good deal more nearly certain as a result of experience. If there are, for instance, two sites of equal technical merit as far as estimates of risk can be made, and one has already been in use safely for several years, then it is more justifiable to continue using that

one. Indeed some existing sites may appear to a hydrologist to be of very doubtful safety compared with others he could suggest, but if in fact they have given no trouble over several years and there is no trace in the water analyses of any contamination at all, it may be better to continue to use such sites rather than change to the apparently preferable but untested new ones. It follows that, whatever conclusions we reach on the subject generally, in so far as the use of tips is quite unavoidable we may expect that many of the existing ones will continue to be used for some time.

173. An extension of this principle may be expressed as follows. If, over some years, a tip has received mildly toxic or polluting waste without any detectable effect on any water, it will be safer for very toxic waste than an untested site however good that appears to be. In particular, it would appear that a tip which has proved safe for house refuse could be used for at least some toxic wastes. A discussion on this possibility seems appropriate at this stage.

5. Use of house refuse tips

174. The disposal of solid industrial waste with house refuse calls for discussion also because of the analogy which at first sight appears to exist with the disposal of liquid industrial wastes in admixture with sewage. An Act facilitating this practice dates back to 1937, and since that time there has been a marked tendency, encouraged we believe by all interests and by central government, to divert liquid industrial wastes to sewers to be treated and disposed of with the sewage of the district. In some cases the proportion of industrial effluent in the sewage reaches 50%. Is there not a similar possibility showing equal advantages with solid industrial wastes and house refuse? In the present chapter only one way of refuse disposal will be considered, controlled tipping, and of course, we are confined by our terms of reference to toxic and related solid wastes.

175. This being so, we have immediately to record the fact that the policy of admitting toxic liquid wastes to sewers without treatment has not in fact been so widely adopted as that of admitting other industrial effluents, and the reason has been because of their toxicity. Many chemicals included in the classification "toxic" slow down or prevent biological purification of sewage, and to a large extent they have had to be excluded from the sewers. Similarly, tipped refuse undergoes "purification" by biological agencies, and it is important that this should take place. After tipping, exothermic biological decomposition takes place, raising the temperature of the refuse which, of course, accelerates the process. Because of this and the long period of consolidation and maturing that follows, a refuse tip can ultimately be reclaimed for agriculture, recreation, or other purposes and this is important. If the biological decomposition did not occur it would be most unfortunate, and any considerable risk of its being prevented by toxic solid waste should not normally be taken.

176. The likelihood of severe trouble of this kind is, however, reduced (compared with that for sewage with liquid toxic wastes) for two reasons. The first is that often biological action is not stopped but only slowed down. This is serious with sewage—if the rate is halved the necessary plant is doubled in size—but with refuse it may not matter if it takes twice as long to heat up or if the temperature reached is not so high. The second reason is that toxic waste in sewage mixes with the whole of it and influences the biological action of the whole plant, but

in refuse it may only contaminate a small part and in the remainder oxidation and sterilisation will go on normally. The final overall difference may not be very noticeable.

177. There is, moreover, another major difference between sewage and refuse, which could be important in this connection. If toxic effluents are disposed of with sewage the effluent on a particular day must be mixed with the sewage of that day; the previous day's sewage has already been dealt with and is in the river and last week's probably in the sea. But this is not so with refuse. Clearly it can be arranged, if necessary, for today's toxic solid waste to be mixed with, or put into the same place as, last year's refuse, which will already have largely broken down biologically. It might, of course, be expensive or inconvenient to do this; it depends on circumstances; thus it might be necessary to complete the tip and reclaim the land by a given date. Nevertheless, it seems clear that, at some cost and trouble, disposal of toxic solid waste with house refuse could be achieved without the toxicity itself being as troublesome as in the case of liquid effluents with sewage.

178. There is another advantage too, which accounts for the matter being discussed in the present chapter. The highly polluting character of the percolate from house refuse has already been described; the purification effected by its subsequent passage through sand has been established; but in the past many refuse tips appear to have been located without much regard to what the percolate might do, yet in no significant case has a large water supply been polluted. Is it not therefore reasonable to argue that where a house refuse tip has been located at what seems a safe site, and where long experience has proved it to be a safe site, then that site would be safe for at least some toxic wastes? Not all such sites would, of course, be available for them, but it appears to us that it would be a suitable direction in which to look.

179. The converse is also applicable. If a source of underground water commonly contains potentially harmful bacteria which must have been carried by percolate from the surface, then it should be concluded that a readily available route for the passage of toxic matter to the water also exists. Accordingly, toxic wastes should not be tipped in the vicinity unless percolation can be prevented or otherwise dealt with.

Chapter XIII—Pre-Treatment of Toxic Solid Wastes

180. We have just considered what tip operators could do to make toxic waste disposal safer, and concluded that there are several promising possibilities. The present chapter is about what industry could do, for they must have a part to play. Further, we have considered the parallelism between toxic solid waste with house refuse and toxic liquid wastes with sewage. Following this up, we must point out that treatment of toxic liquid waste with sewage is facilitated, indeed is often only made possible, by pre-treatment of the waste to remove or reduce its toxicity. We must expect the same to be true for toxic solid waste disposal, either with house refuse or separately.

1. Reduction in quantity

181. Sometimes a reappraisal of manufacturing processes enables a reduction in the volume of effluents to be secured. This saves water, reduces (usually) the charge for purification levied by the local authority, and enables any treatment or balancing of flows to be carried out in smaller plant. Similar action with toxic solid waste may be possible and may offer an even greater compensation, because transport and handling may be the major disposal charges and are directly related to volume and weight. A relatively small reduction in quantity may allow the waste to be taken to a more distant, but safer, site at the same cost.

182. Allied to reduction in quantity is suitable segregation of different wastes. This is often desirable (though sometimes very expensive) for liquid wastes; the weaker ones might then be disposed of without treatment, and the stronger ones might justify treatment which would be very expensive for all of them. So, if only a fraction of a firm's solid waste is highly toxic, segregation may permit most of the waste being disposed of cheaply nearby, in which case the cost of taking the smaller proportion of toxic waste a considerable distance might appear very reasonable. Segregation would show up to particular advantage when different fractions of the waste should preferably be disposed of in different ways, and not merely on sites of different degrees of safety. For instance, if part of the waste is toxic and will burn and part is inert and will not burn, segregation permits the most suitable method to be adopted in both cases at a cost probably lower than proper disposal of the whole by either method alone.

2. Reclamation

183. The economist's definition of a waste is presumably that which it is cheaper to throw away than to make further use of. This does not mean that waste is

valueless; some of it certainly is not. The situation would be quite different if raw materials became much more expensive and costs of disposal were vastly increased. But no one wants increased prices simply in order to ease the waste disposal problem (or, indeed, for any other reason!). Nevertheless, we are inclined to the view that the "economist's" definition of a waste is inadequate. Partly because this definition concerns one user only; it might be economic for him to throw something away, but uneconomic for the nation (or mankind), particularly in the long run. Partly, however, it is because if that definition were all, the attitude of those who might suffer as the result of waste disposal is likely to be hard and unsympathetic. Why, they will ask, should our water supply be put at risk, even at a negligibly small risk, and why should our enjoyment of the countryside be spoiled, merely because it is cheaper for industry to throw something away than to use it? And there is no convincing answer to that question unless, of course, the risk to water and the spoliation of the countryside can be put into economic terms and added to the cost of disposal. The attitude of these potential sufferers would be much more co-operative if they were convinced that the wastes difficult to dispose of really were the quite unavoidable consequences of legitimate and beneficial industrial activity and not just by-products discarded merely as the cheapest way out. We think that such a co-operative climate should be fostered, and that industry should play a major part in fostering it. So we believe that a firm should not look at the possibility of reclaiming materials from its toxic wastes solely from the angle of "Will it pay?" A broader attitude might well bring them tangible benefits in the long-run.

184. We say this here because there do appear to be opportunities for reclamation which are rarely taken advantage of and which may not be really economic in the strict and narrow sense of the word but which would solve or ease waste disposal problems which public authorities find embarrassing. Some waste oils provide examples. It is true that in these days of highly specialised oils it may not be feasible to take waste oil of uncertain origin and reclaim it for a specialised purpose. But it can usually and usefully be recovered and burnt in suitable central-heating plants or for some other similar purpose. That this is not always done is probably due to the high cost of collecting relatively small quantities, combined with the low cost of fuel oil. Also, the costs of disposal of waste oil may not in fact be great. But risk to water supplies and rivers, though maybe small, is seldom absent, and discarded oil on tips can be a great nuisance; and we believe that, overall, it would be a good thing, even if not strictly economic, if reclamation were more widely practised.

185. Again, both in this country and the USA, acid sludges from petroleum refining have been burnt, and the oxides of sulphur in the products of combustion used for the manufacture of sulphuric acid, which may be regarded as having been reclaimed from the original sludge. The residue from the burning is virtually inert and easy to dispose of.

186. It may also be possible to reclaim waste cleaning fluids of the trichlorethylene type; but we have not the detailed knowledge of processes, specifications, costs, and local difficulties and conditions which would be necessary before we could say that this or that material ought to be reclaimed from this or that waste. We understand that work on reclamation of useful materials from scrap and waste is on the programme of the Warren Spring Laboratory of the Ministry of Technology. We merely wish to emphasise that reclamation should be investi-

gated more than it has been in the past, and that a decision on it ought not always to be based merely on the simple economic case.

3. Detoxification

187. Toxic substances are seldom chemically inert, and some of them can be converted to a non-toxic or less toxic compound, or to a less dangerous form, by chemical treatment. Such processes, however, may be quite impractical or prohibitively costly, and it is not suggested that the toxic waste problem could be solved by making all of them non-toxic. Part of the difficulty is that solids often need to be brought into solution in order to be chemically treated, and this means a liquid effluent problem and probably a sludge problem, which present their own problems in disposal even if they are non-toxic.

188. However, cyanide can be decomposed by chlorine, and the product is relatively non-toxic. It can also be destroyed biologically as can phenol and some other toxic materials. Chromates, which are toxic in water and may in certain circumstances cause fires, can easily be reduced to chromic salts which are relatively free from such properties. Many metal salts can be precipitated as oxides or hydroxides, in which form they are almost insoluble and hence without risk to water supplies. We are not aware of any specific instance of such processes being carried out on solid wastes as a routine, but they are used for liquid wastes and could be adapted at a cost in money and convenience to solid wastes. We believe there could be circumstances where the adoption of such processes could properly be demanded, though in other cases they might be quite unnecessary.

Chapter XIV—Sludges from Pre-treatment of Liquid Toxic Wastes

189. Mention has been made of instances of treating liquid effluents to remove toxic constituents from them prior to discharge to the sewers. In these processes the toxic constituents, often metal salts, are precipitated as sludges and are separated by sedimentation or filtration. These sludges are usually called toxic sludges, and their disposal is sometimes difficult to arrange. That a local authority could properly have a part to play in their disposal seems to have been accepted by Parliament as long ago as 1937, since the Public Health (Drainage of Trade Premises) Act of that year, in Section 7(2), makes it possible for a local authority and trader to enter into an agreement under which the former should undertake to remove and dispose of "substances produced in the course of treating any trade effluents". So far as is known, however, this section has not been widely used, but Parliament recently enacted the same provisions in Section 37(5)(b) of the Sewerage (Scotland) Act 1968.

190. In principle, we believe that the metal content of such sludges should be reclaimed. The metals usually included in the term "toxic metals", such as copper, chromium, cadmium, zinc and lead, are neither plentiful nor cheap, nor are the world's resources unlimited, and a policy of reclamation and conservation of them must in the long run be right. Sometimes they may be recoverable at the factory treating the effluents, but this may not be generally practicable. We think there may be scope for a commercial service for collecting the sludges, perhaps after dewatering, for transportation to a suitable processing works for reclamation there.

191. But we also realise that in some cases this would be impracticable or inordinately expensive. Some of the sludges will require to be disposed of as such, and the obvious way of doing this is by tipping. In our opinion, tipping with reasonable precautions of sludges resulting from precipitation of metal oxides from toxic metal wastes should not present any appreciable hazard to underground or river water quality. The water in equilibrium with the sludges as produced will have the same composition as the liquid from which the sludges separate, namely, fit for discharge to sewer or river according to requirements. Its presence, therefore, as a small fraction of that draining from the tip and as a very minute fraction of that being drawn from any source in the aquifer, should not be a hazard at all. Moreover, it would separate from the sludge only very slowly (one of the difficulties about such sludges is to dewater them), and penetration of the sludge subsequently by percolating rainwater should be equally slow. The amount of metal oxide which would dissolve in this would be quite

minute unless acid wastes had been disposed of nearby and the acid contaminated the percolating water. Prevention of this is about the only precaution needed in the interests of safe water, though in certain circumstances it is just possible that the effect of reducing conditions may have to be considered.

192. Water protection is not, of course, the only factor to be borne in mind. If the tip were later reclaimed for agriculture, or as a park, the metal content might interfere with plant growth. This could be avoided by ensuring that the sludge was always sufficiently far (say 3 ft.) below the final surface level. It would also be necessary to take precautions to ensure that the physical presence of sludges did not produce undesirable effects, for example by permitting the whole tip to move. This could be coped with, we believe, even if de-watering or some limitation of quantity of sludge were necessary. Troubles in this direction should be no more severe than those given by inert sludges and slurries.

193. On the whole, then, we do not see that disposal of sludges from metal effluent treatment plant and the like should be a difficult problem in spite of what may sometimes be called their "potential toxic hazard". All such a phrase means is that they could be toxic under conditions very different from those which could possibly exist when disposed of in the proposed manner. They may be safely disposed of on any site which is considered reasonably safe for house refuse, and possibly elsewhere depending on local assessment and local needs.

Chapter XV—The Disposal of Aqueous Toxic Wastes to Tips and in Other Ways not Involving Methods Covered by Special Legislation

194. We explained in our introduction why we came to deal with toxic liquid wastes when they are disposed of by tipping and similar methods. Discharges of such wastes to sewers, rivers, estuaries and aquifers are adequately controlled by the Acts mentioned in Chapter XI. Discharges to the sea are not controlled so directly, but do not appear to give much trouble. Discharges on to the land surface are not covered by statute law, but are rare except for some effluents which it is hoped will be purified during that method of disposal. But discharges to the land via waste tips are not only not covered by existing law, but represent a practice which in some parts of the country is growing rapidly. This is a matter of concern to us, particularly as it appears that in order to dispose of more than minimal quantities of liquid wastes on tips it is necessary to avoid taking most of the precautions we have described as being desirable for the safe tipping of toxic solid wastes.

195. We should make it plain that in this chapter we are dealing with aqueous, non-oily wastes only; oily and tarry wastes are considered later.

196. The Acts referred to above not only control the disposal of liquid wastes in the ways mentioned, they give the industrialists rights to dispose of their wastes, subject to conditions and to appeal. It is therefore appropriate to ask why, this being so, manufacturers do not take advantage of their rights in respect of those aqueous wastes which they now dispose of to tips. One suggestion made to us was that sewerage authorities have refused to accept those wastes into their sewers. On this all we can say is that if so the traders have not, so far as we can ascertain, followed up their rights by appealing against the refusal. It is quite possible, however, that the traders accepted the refusal as reasonable and felt they had no hope of a successful appeal. It is also possible that they knew that the conditions (including charges) laid down by the authority, or those they felt would be laid down on appeal, would cost them more, and give them more trouble than disposal to a tip. In some cases they might not know how they could fulfil the conditions, and would not feel inclined to undertake what might be a long and expensive investigation in order to be able to adopt a conventional method of disposal at a cost considerably greater than an unconventional one open to them.

197. At a late stage in our investigations the Confederation of British Industry carried out a small survey, covering some 500 firms, of costs of disposal of liquid waste by contractors (and presumably to tip) and by themselves to tips. Where contractors were employed the minimum cost was £1 per ton and the average

was £2·1 per ton. Where the firms carried out the disposal, costs were lower, averaging £0·35 per ton. It is submitted that if such costs were lower than those of treatment, then on average, the liquids must be particularly difficult and costly to treat. It certainly seems that this is a reasonable conclusion to draw, though in some cases the manufacturer might prefer to pay rather more for a method of disposal which saves him the trouble of treatment and the anxiety lest the degree of purification were insufficient to satisfy the local sewerage or river authority.

198. Generally speaking, and subject to what is said elsewhere about pure economics, no one can blame an industrialist for disposing of an unwanted by-product as cheaply as he can providing he runs no risk of damaging other people's rights and properties in so doing. It is because we believe that tipped liquids may do this in circumstances when tipped solids would not that we are so concerned about liquids. An investigation of the practice is clearly necessary.

199. When a waste solid is tipped the general intention is that it should stay indefinitely where it is put. One of our principal concerns has been the effect of percolating rainfall which, by dissolving toxic matter, takes it away from where it has been put and raises a threat to rivers or underground water. We have been at pains to point out how small the amount of natural percolate really is, and we have made suggestions both for preventing the percolate reaching the waste and preventing the percolate from the waste reaching groundwater. Those suggestions are in the interests of safety of water.

200. But when a liquid waste is "tipped" it only stays put when forcibly prevented from getting away. It is to be expected that, unless prevented, the liquid itself will percolate through the tip and either reach river or underground water. This seems to us a fundamental difference between liquids and solids, and it must mean that the risk of pollution from tipped liquid waste is, other things being equal, far greater than the risk from solid waste. It seems also to be true that, judged from the disposer's angle, the quicker a liquid soaks away the more satisfactory the mode of disposal is regarded and the more liquid can be disposed of on the same site. But, again other things being equal, the quicker a liquid soaks away the quicker it must reach the water below, and the more liquid is disposed of on the same site the greater the risk of pollution. We thus have the most disquieting situation that the most obvious evidence of successful disposal of a liquid waste by tipping is also the most obvious evidence (short of its actually occurring) of a risk of water pollution.

201. It does not necessarily follow that in every case pollution will, in fact, occur. A clay barrier may prevent vertical percolation, and horizontal percolation may result in springs discharging at points of no importance to anyone (e.g. in the lower reaches of an estuary or even the sea). Through percolation the liquid may be exposed to biological destructive agencies for a period of possibly several months, and a good deal of purification may be effected. Neutralisation may take place. Adsorption or absorption may occur, and hold up toxic matter almost indefinitely. There may be sufficient suspended matter in the liquid to block up interstices in the soil quickly and prevent further penetration, and so on. Nevertheless, the risk of pollution from disposal of liquids, particularly aqueous liquids, must greatly exceed that from disposal of solids, and "approval" of a tip for disposal of liquids must clearly be far more difficult to give.

202. However, some of us have personal knowledge of tips which now receive large quantities of liquid wastes each day and where trouble neither occurs nor is expected. There are sites which have been "approved" over many years for house refuse where a clay layer between the tip and the underground water must definitely exist and where, if springs of polluted water arise (as they do), they are of no particular importance nor are likely to be. There are also tips where polluting liquids have left the site, though the trouble is not yet serious and may never be. Similarly there are tips which have inadvertently received large quantities of a particular liquid waste and the threat to groundwater was such that every effort was made, by excavation, to remove as much of it as possible. There is, therefore, a wide variety of risks with liquid toxic wastes; their tipping cannot be condemned out of hand but approval might prove very difficult to give.

203. There is also an indirect danger of water pollution attributable to the tipping of liquids (not necessarily toxic ones) on industrial tips. Their percolation through the tip might be expected to wash out any soluble toxic material already there. They might cause the disposal of toxic solids to be dangerous in circumstances where they would otherwise be safe.

204. In certain parts of the country there are tips of relatively inert waste on to which toxic or highly polluting liquid waste has been dumped for a long time, and from which the drainage could be sampled and analysis has shown the drainage to be much less polluting than the original liquid wastes. In fact, biological oxidation has taken place and the inert tip has acted as a bacterial filter. There is no harm but much advantage in this, provided the percolate can be disposed of more safely, and it is in fact an ingenious way of taking advantage of an unexpected resource—biological purification capacity in a tip.

205. With such a variety of possibilities and experience it is impossible to generalise about the tipping of liquid wastes, but we certainly think it is much harder to justify than the tipping of solid wastes, and that the person who wishes to do the tipping (manufacturer or tip owner) should be expected to provide pretty good evidence to the appropriate interests that pollution will not in fact result, or if it does it can be dealt with, before he is allowed to carry out the tipping.

206. It will be appreciated that this does not necessarily apply to small quantities of liquid waste which should do no more than saturate dry solids which have previously been tipped and if it is proposed to take some action to prevent natural percolation later. Such capacity could, for instance, be used to receive toxic sludges, though if too much were applied the stability of the tip might be affected. It could also be used to receive limited quantities of difficult liquids which are produced only sporadically. We are informed that one of the major problems of certain industries is the disposal of liquids arising occasionally from reactions that have behaved abnormally, and these liquids may have to be disposed of in a hurry.

207. What then must be done with aqueous liquid wastes? For we must remember that we are required to suggest facilities for disposal which would be safe. Fortunately, there are ways of disposal which are in principle safer than tipping.

208. The first is the normal method of disposal to sewer or river after any requisite treatment. This is clearly not the answer in many cases. It might be more

expensive than tipping; in fact it usually would be for those liquids at present being tipped, because this practice would not have been started had it not been cheaper than sewer or river discharge. Sometimes it would be too expensive for the firm to bear and remain solvent, or even quite impracticable.

209. They could be disposed of to a deep, abandoned, dry mineshaft when conveniently available. Because the workings below are deep and dry they could be assumed to be below the water bearing strata and hydraulically isolated from them. Hence, pollution would be no risk. Liquids could be disposed of there more easily than could solids.

210. They could also be disposed of to sea by way of sewer or pipeline or with sewage sludge, though it would have to be reasonably well established that no significant ill effects would be caused.

211. It would appear, in fact, that there are often a number of choices, taking advantage where possible of the fact that liquids generally are easier and cheaper to load, transport and discharge than are solids; they can be conveyed by pipes and tankers, and they can be pumped.

Chapter XVI—The Special Problem of Oily and Tarry Wastes

212. For several reasons these wastes deserve discussion quite separate from either solid wastes or aqueous wastes. Unlike solid wastes they need not stay where they are but can travel underground without the need of percolating water to carry them along. Unlike aqueous wastes they may travel only very slowly, much more slowly than water would and, depending on their viscosity and the pore structure of the permeable rock, they may in fact be held back almost as a solid is. On the other hand, less viscous oils may travel very quickly. They can be of almost infinite variety, from water containing some light oil to something almost as viscous as pitch, from inert mineral oil to tarry materials which are highly acid, and from oils which have no water-soluble constituents to those the chief danger from which is their content of toxic or other objectionable water-soluble matter such as phenols. It would be most difficult, therefore, to lay down specific rules for the disposal of these wastes as a class.

213. Cases of pollution of underground water occurring from the tipping of oily wastes are, as for other wastes, rare. There have been a few cases of groundwater being contaminated with constituents of gas works tar, though they have arisen from a leakage of tar from pipes and storage tanks rather than from tar disposed of by tipping. In one of these cases it appeared that the tar must have been present in the ground for nearly a century before it gave trouble. There have also been cases of spillage of fuel oil and aircraft fuel. At least one of these in this country gave some contamination to a public water supply, though surprisingly little, but there have been other cases abroad. At least one considerable spill of fuel oil in the chalk has had no discernible effect on a large quantity of water pumped from less than a mile "downstream" over several years.

214. In Chapter XIII we discussed reclamation of materials from wastes and made special mention of recovery of oil from oily wastes. Because of the difficulties of disposal of such wastes we would like to emphasise this point again, though we are aware that in some cases, as for instance with oily wastes which are acid in addition or contain solid matter, this may not be easy. In some cases, we understand, the difficulties have been satisfactorily overcome.

215. Many oily wastes are quite viscous, and slow travel underground would be expected. The rate of travel through interstices could be very slow, and it could be that in its passage through them it would form an emulsion (if they were previously filled with water) or a foam (if they had previously been filled with air). In either case the viscosity would be increased and the rate of percolation further reduced. It is not known if it would eventually stop, but if it did the waste

could thenceforth be regarded as a solid, even as a solid from which toxic matter could not be leached out. This is perhaps one of the subjects on which research would be profitable, and we shall recommend this. If waste oil underground could be relied upon to become of the same consistency as some of the masses of "oil" one frequently finds on beaches, then it could readily be accepted that it would hardly move in the ground at all and be very little penetrated by the percolate. It would only give trouble if excavated later, and it might continue in this state for many decades.

216. For oily wastes which cannot be burned or reclaimed, underground cavities and abandoned mines of proved safety may be the safest and cheapest method of disposal. Care might have to be taken to avoid the more unpleasant possible effects of mixing different kinds of waste, but otherwise disposal would be simple and safe.

217. Disposal of such wastes to sea would not appear to be as satisfactory as disposal of either solid wastes or aqueous wastes there. The oil would be expected to float to the surface and become unsightly, though in the middle of the ocean this itself would hardly matter. The public however has shown such concern at the pollution of the sea by oil that it would seem inadvisable to dispose of oily wastes there at all if satisfactory ways of disposal are reasonably available elsewhere. Sometimes however, oily wastes may be impracticable to treat, difficult or dangerous to burn and unsuitable for tipping at any available site. In such circumstances, consideration could be given to sea disposal provided the adverse effects of it can be avoided. For instance, mixing with a non-toxic dispersing agent might prevent a surface film forming, and a suitable selected site might ensure quick dilution with some thousands of times its volume of sea water. Acidity would be automatically neutralised, and biological destruction of the oily matter would probably occur in due course.

Chapter XVII—Disposal of Toxic Wastes with Sewage Sludge

218. A good deal of digested sewage sludge is finally applied to land which grows crops, and the intention is that its nutrient constituents should be utilised and that its organic constituents should continue their biological breakdown under natural conditions, which might itself be profitable to agriculture by providing soil "humus". The sludge may or may not be de-watered before application to land, and sometimes (on the small scale) it is first fortified with additional plant nutrients.

219. It almost goes without saying that toxic wastes, liquid or solid, should not mix with sludge thus disposed of. Indeed, some sewage sludges as produced cannot be disposed of in this way because of their content of toxic materials from liquid wastes admitted to the sewers.

220. But some sewage sludges are just dumped. No use can economically be made of them, and the sole concern is that they should be disposed of safely, permanently, and without creating a nuisance. If these matters are ensured it seems likely that safe disposal of at least a proportion of toxic waste mixed with the sludge would be ensured at the same time. This applies particularly, perhaps, to disposal at sea, which is adopted by some of our largest sewage disposal authorities and which, in spite of periodical objections on the grounds that it is either wasteful or dangerous, shows every sign of retaining, if not increasing, its popularity.

221. Roughly speaking, the amount of sewage sludge produced, assuming 5% solids content as a typical figure, is about ½ ton per head per annum. Thus, a city of 1 million inhabitants produces about ½ m tons of wet sludge every year, which would give a minimum 500-fold dilution to 1,000 tons per annum of toxic wastes. Further dilution occurs immediately the sludge is discharged; the amount is not well known, but it seems reasonable to expect that discharge from a boat would quickly give the amount of dilution given to sewage (or sludge) within 200 or 300 yards of being discharged from an outfall some 2 or 3 fathoms deep. This could well be another 200–500-fold, making in all a dilution of 100,000–250,000-fold. Such a dilution might not be adequate to make all toxic wastes safe, but it would be for many of them. It seems to us that there is a place for disposal of at least some wastes with sewage sludge to sea, and we are glad to learn that some local authorities are planning to offer some kind of service to industry based on this. Of course, care would have to be taken in the choice of wastes to be accepted; it is possible to abuse as well as to use any method of disposal; but within limits and under intelligent control it could be used without risk, and in some cases it might combine safety and economy better than any other method.

Chapter XVIII—Disposal of Toxic Wastes by Incineration

222. Incineration is an effective way of disposal of much combustible organic and chemical waste. Usually some residue is left, but it is much smaller in bulk and weight than the original waste. This can be a great advantage of incineration, which may from one angle be regarded as pre-treatment of a waste before tipping. It is, however, a process which costs money if it is to be efficient and nuisance-free.

223. For toxic wastes, incineration often offers a further major advantage which may also apply to highly polluting wastes, oily and similar wastes. The toxic constituents may be burnt or otherwise decomposed at the temperature of incineration and thus cease to be toxic; the organic chemicals generally are converted to carbon dioxide and water and relatively simple compounds of nitrogen, sulphur, phosphorus, chlorine and so on. Or, at the temperature of incineration, the toxic materials may undergo changes in physical form or combine with other substances usually present so that the toxicity is, so to speak, less readily available; thus, a powder may become a slag and therefore much less readily soluble in water. It is this type of advantage which makes incineration specially attractive for toxic solid or semi-solid waste and other highly polluting wastes.

224. Incineration has the disadvantage of being liable to give rise to air pollution which would not otherwise occur. In our view, however, experience indicates that technology for controlling this to produce acceptable levels of emission to air is either already available or could reasonably easily be developed where necessary.

225. The wastes that can most easily be dealt with by incineration are those which have a sufficiently high calorific value not to require the use of additional fuel to support combustion once ignition has been initiated. Prominent among these are the oily wastes, including acid tars, and mention has already been made of recovery of useful heat by combustion of waste oil. Also, there is no reason why the heat produced on combustion should not be employed in incinerating wastes of low or no calorific value. This, however, assumes that the incinerator would be dealing with more than one type of waste, which may not always be desirable.

226. The design of an incinerator to operate satisfactorily and without nuisance is by no means an easy job, and in our view to construct an incinerator which is really efficient is more important than to provide for maximum utilisation of heat produced or to make it suitable for a wide variety of wastes. Accordingly,

although many incinerators are intended for mixtures of wastes, we think there is scope for purpose-built incinerators for special types of waste. It is just not possible to specify in detail incinerators suitable for the entire range of waste toxic materials for which they could be used. After ensuring that incineration will take place effectively, it is most important to be certain that the installation will be capable of meeting the requirements of the Clean Air Acts and, when necessary, the Alkali Acts in regard to emissions to air.

227. As long ago as 1958 a sufficient number of manufacturers had turned to incineration as a method of dealing with their difficult wastes that it appeared desirable to bring the air pollution aspects of such incineration under the control of the Alkali Act. This was effected by the Alkali, etc., Works Order of that year when "Chemical Incineration" works were first scheduled. Experience showed that the definition of such works in the 1958 Order was not sufficiently wide and it was consequently extended by the Alkali, etc., Works Order of 1963. The definition of this class of works now runs:

> "*Chemical Incineration Works:* Works for the destruction by burning of wastes produced in the course of organic chemical reactions which occur during the manufacture of materials for the fabrication of plastics and fibres and works for the destruction by burning of chemical wastes containing combined chlorine, fluorine, nitrogen, phosphorus or sulphur."

228. This definition appears wide enough to include incinerators for most of the wastes with which we are concerned, and we understand that by the end of 1968 19 works in England and Wales and 8 in Scotland were registered as operating such incineration processes. Other installations not falling within the definition are also known to be in use.

229. The first statutory requirement of an incinerator is that the furnace shall be capable of being operated smokelessly. This nearly always means that the incinerator must be fitted with an after-burner to consume the smoke produced in the furnace in which the primary combustion takes place. Where the waste being burned is of low calorific value, both the furnace and the after-burner may have to be provided with a fuel supply or burners to maintain sufficiently high temperatures.

230. Where a mixture of wastes is being dealt with it is often possible to manipulate them so as to maintain their proportions so that the calorific value is sufficiently high as to maintain primary combustion, though auxiliary firing of the after-burner may be required.

231. There could be problems of particulate emission requiring to be dealt with under Statute but often the materials being burnt contain little ash, so that this presents no difficulty. Where there is emission of a "noxious or offensive" gas—e.g. hydrogen chloride—a water or soda scrubber must be used, preceded by some form of cooler since the gases leave the furnace at an elevated temperature. This is commonly a void tower down which water is sprayed. The scrubber, fan and final chimney must be corrosion resistant. Fibre-glass is a favourite material for the final chimney.

232. Practically all the "difficult" wastes being burned at present are sludges, viscous liquids or solids that melt below ignition temperature. The furnaces therefore necessarily have a solid hearth with primary air for combustion being

injected over the top of them. Since chemical wastes of this nature are likely to be increased that type of furnace will probably be more widely used. For wastes which are solid and remain solid at combustion temperatures there could be a place for grate-type furnaces.

233. Incinerators at present in use are often dealing with more than one type of waste. For example, one is taking a mixture of general factory waste, including paper, tarry chemical residues and waste solvents. It has four "combustion cells", two for general waste and the other two for tarry residues and solvents separately. Another incinerator burns antibiotic residues and waste ether. Other wastes incinerated include those arising in the manufacture of nylon, maleic and phthalic anhydrides, poly-urethane, bipyridyl, fluorinated hydrocarbons, acrylates, polystyrene wastes, plastic offcuts, PVC and methacrylate.

234. Incinerators tend to be costly, since they must not only be designed to burn the waste in question but must do so safely, efficiently and without objectionable emissions to air. They must also resist high temperatures and often highly corrosive gases and liquids. It is impossible to generalise on capital or running costs.

235. Incineration is also a process for disposing of house refuse (or treating it before disposal depending on the point of view). Some large units have been built in recent years. It is not for us to speculate on the place which incineration will have to play in the future; at present it is not a very large one. But it does seem to be our duty to consider how far, if at all, house refuse incinerators can assist in the disposal of toxic and other difficult industrial wastes.

236. Although house refuse is a most heterogeneous waste product, nevertheless incinerators for it must be purpose designed and built, and it must not be expected that they would normally be able to take large quantities of toxic industrial wastes without impairing the performance of their primary duty. But it is not unreasonable to suggest that they could also deal with toxic solid and allied wastes provided the quantities, nature and properties of these were such that the properties of the mixture dealt with were within the design limits. The wastes would need to be readily handleable and present no risk to the handlers which could not be overcome by reasonable precautions; the mixture would need to be comparable with house refuse so far as combustion properties were concerned; and the combustion products not significantly more corrosive nor more polluting to air than with house refuse.

237. All this suggests that refuse incinerators could assist in the disposal of toxic solid or semi-solid waste in two sets of very different circumstances. The first is when the amounts concerned are very small; it is, we think, plain that, provided it can safely be incorporated in the waste being burnt, sufficiently small proportions of even the most highly toxic wastes could pass through the incinerator without harm to the process and, provided they were of a type destroyed by incineration, without making the products (ash and combustion gases) less suitable for normal disposal. The second type of waste is that which is in general similar to normal "refuse" but which has been contaminated by very toxic solid or liquid materials. For instance, used containers which are contaminated with some toxic materials may not be suitable for tipping on the sites locally available but could be disposed of by incineration if uncontaminated containers of the same type would be acceptable.

238. Within these limitations normal refuse incinerators could not dispose satisfactorily of large quantities of difficult wastes, but could certainly assist in the solution of some difficult and embarrassing problems which arise from time to time. We believe they could play a useful part in the overall task of safe toxic solid waste disposal.

Chapter XIX—Permanent Storage of Wastes

239. We are not quite sure how the Courts would interpret the expression "dispose of", but we feel that a waste which is deliberately placed somewhere where it can be both examined and recovered if necessary has not, in fact, been disposed of; it has been put into permanent storage. Disposing of it would include the step of abandoning it altogether. It is believed that some radioactive wastes are so very highly active that they must not be abandoned; they are put into permanent safe storage. The question arises whether any toxic wastes are so dangerous that it would be unsafe to abandon them anywhere, even after enormous dilution.

240. We do know that there are substances which could have profound biological effects at almost infinitesimal concentrations—witness the recent pollution of the River Rhine, when a reputed 100 kg. or so of a substance was nevertheless lethal to fish in this extremely large river. Most normal methods of disposal without destruction would appear to be unsafe for such substances. But most, if not all of these substances are organic, and even if not flammable themselves could be destroyed in a suitable incinerator, and this would be intrinsically far safer than permanent safe storage. It should, in our view, be the chosen method of disposal, except where some alternative, for example chemical destruction, shows up to advantage. In any case permanent safe storage would not be the best answer, and we doubt if there is a place for it in the disposal of solid toxic wastes.

241. This appears to be the place to advise that a toxic waste should never be put into store merely because no one can think what to do with it. This certainly has occurred, particularly with surplus laboratory chemicals which are easily set aside until someone decides what to do with them. Later they become nobody's business and they remain in store until the building must come down or be used for another purpose. By that time labels may be lost, no one knows anything about the substances, and they are a source of embarrassment.

242. In our view, if a material really is waste it should be disposed of in a reasonably safe manner with reasonable dispatch, though with no undue haste. It may be desirable to seek expert advice, and necessary to secure formal permission, it may be essential to await the accumulation of a sufficient quantity of waste to transport it to a disposal site economically; or it may be necessary to store the waste to fit in with a pre-arranged timetable of disposal. Apart from such matters, however, delays are dangerous.

Chapter XX—Disposal to Sea

243. The amount of water in the seas and oceans of the world is almost unbelievably great, and its potentialities for dilution and rendering harmless the wastes of mankind are almost infinite. Unfortunately, these potentialities are not fully available everywhere because the oceans do not mix rapidly, and in some places are hardly available at all. Disposal of wastes at these places (chiefly sewage, but also toxic industrial wastes together, of course, with waste oil) has at times given rise to objectionable conditions and has tainted fish and even made them poisonous to mankind. This has given rise to concern, both popular and scientific, and sea disposal of wastes has come in for a good deal of criticism.

244. However, if a method of doing something fails now and again the correct thing to do is not to abandon the method (particularly if in theory it is a good one) but to find out why it fails and what makes it succeed, and then to develop techniques of operations, or adopt the necessary precautions, so that it will not fail. This should be the attitude towards sea disposal of wastes.

245. We have no figures for the amounts of waste disposed of to the sea, and no knowledge of what proportion of these is toxic waste. The vast quantity of sewage sludge which has been discharged a few miles from the shore for many decades is testimony to the capacity of the sea to receive large amounts of wastes without significant effect, and a few special studies have confirmed that at suitable sites enormous dilution is readily available and biological purification takes place. There are cases, too, of toxic liquid effluents being discharged to sea or estuary without trouble ensuing. The disposal of toxic solid waste to sea is more limited in extent and is generally carried out at sites which are intrinsically very safe, i.e. in water deeper than 2,000 fathoms and beyond the edge of the Continental Shelf.

246. Within territorial waters of England and Wales bylaws of Sea Fisheries Committees operate, but there are no such Committees in Scotland. Beyond that there are no statutory powers of control. Suitable precautions are taken in England and Wales, however, through a voluntary consent system operated by the Ministry of Agriculture, Fisheries and Food, and it is believed that this is working well. The consents for deep sea disposal usually request that the toxic material shall be enclosed in suitable, identifiable, non-plastic containers which will not float, and from which the wastes will not be released before they have arrived at the bottom of the sea and then only very slowly. The disposal itself is carried out from ships carrying cargo on transatlantic runs. In addition, the UK Atomic Energy Authority has gained experience in sea disposal of wastes,

initially because of the requirement that disposal of waste radioactive materials should be very safe indeed. These, of course, are not our concern, but the research carried out on sea disposal will have its general application to non-radioactive wastes also. UKAEA are consequently considering offering to industry both advice and facilities for the disposal of difficult wastes, to the sea and in other ways, and an announcement of such a service on a repayment basis has recently been made.

247. There are a number of well established areas in the sea in which much dumping of unwanted material has satisfactorily taken place. Each dumping is entered in the ship's Log, and a certificate signed by the Master of the vessel and quoting the consent number, details of the containers and the dumping position, is sent to the Ministry of Agriculture, Fisheries and Food.

248. Bearing in mind the almost infinite slowness with which very deep sea water mixes with ocean layers nearer the surface, the almost infinite amount of dilution which must occur before any trace of the waste could possibly reach the upper and biologically important sea water, and the almost infinite time available for biological and chemical action to destroy or adsorb the toxic materials, it is difficult to imagine how such disposal could be unsatisfactory. It should not, of course, be adopted unnecessarily or indiscriminately; it could be desirable to limit the discharge of a few materials. It is also right to keep records of what has been done. Subject to this, however, and in cases where destruction by, for instance, incineration, is impracticable or dangerous or otherwise unavailable, and when tipping even on "safe" sites it not sufficiently safe or practicable, then we would recommend deep sea disposal.

249. Indeed, in many cases, we think disposal to the less deep parts of the sea would be safe and satisfactory, and we believe experience supports that view. It may be that this applies particularly to liquid wastes unsuitable for discharge to sewers carrying sewage to be treated. This may be a fortunate circumstance, for we have earlier expressed our views about disposing of liquids by tipping. We believe that there is a good case for expanding the practice of sea disposal (as distinct from deep ocean disposal but in many cases well beyond the 3-mile limit), particularly for semi-solid and for certain liquid toxic wastes. But we do not think it should ever be adopted without careful selection of disposal sites in relation to the nature and quantity of the waste and evidence sufficient to meet the circumstances of the case that it would be safe and satisfactory.

250. We do not suppose that sea disposal of wastes will ever become an exact science, but studies at present in progress, both in this and other countries, on rates of mixing and diffusion and on current direction and velocities, coupled with investigations, where possible, of the effect of present practices, are beginning to make possible at least some approximate calculations. If such calculations can be made, and a large margin allowed for error and as a safety factor, then sea disposal of certain wastes could be adopted with confidence. Thus, if it is known that a 1,000-fold dilution of waste will make it innocuous, and if calculation shows that dilution within 100 yards or so radius of a deep-sea disposal point is 100,000-fold, then the "safety factor" of 100 (i.e. the ratio between these figures) should be adequate to cover all uncertainties and permit the disposal of the waste without risk.

251. In recent years concern has been expressed in some scientific circles lest some seas which are small compared with the oceans and receive wastes directly or indirectly from large industrial regions (the North Sea is one such example) are being adversely affected by them. In 1967 the International Council for the Exploration of the Sea set up a Working Party to assemble factual data relating to the North Sea. Its Report (Co-operative Research Report Series A, No. 13) disclosed little in the way of significant pollution, and that is generally quite local, but further research has been recommended.

252. Concern has been expressed about one form of sea disposal which we think it right to mention here. Few local authority sewage discharges direct to the sea are subject to any external control (except in such parts of the sea as come within the scope of the Clean Rivers (Estuaries and Tidal Waters) Act 1960, and certain Ministerial Orders) and normally the sewage is discharged untreated. Usually it contains such industrial effluent as is produced in the local authority's area, but in many cases this is small because the communities are largely holiday resorts. But because the sewage is discharged untreated, industrial wastes could be accepted into the sewers which could not possibly be allowed in more normal circumstances. These wastes might be very highly toxic in themselves or be inhibitory to biological processes. They might have an adverse effect on the sea near the discharge point very different from and much greater than that of domestic sewage, yet the discharge is not under the control of any external authority. Such a situation is open to abuse, though whether it is actually abused to the extent of causing harm we do not know. The coastal local authority could, for instance, accept toxic liquid or semi-solid wastes brought by tanker from outside its area and discharged to its sewers. This would sometimes be wrong, but by no means always. The dilution with sewage before reaching the sea might be a very considerable advantage, and the procedure could mean better disposal at a lower price. But it seems anomalous that discharge of industrial wastes to sea in this indirect way should not require the same consent as it would need if discharged separately at the same place. We doubt, however, if the present situation is so serious as to merit any recommendation about it from us.

253. In summary, we feel that there is good reason to make use of sea disposal of some wastes which it would be unsafe to dispose of in the more usual ways. This applies to disposal by pipeline or in other ways not far from the shore, and disposal by boat to deeper water and even to the deepest parts of the ocean in extreme cases. The cost of deep sea disposal should prevent unnecessarily large demands upon it, and only very rarely will it be necessary to prohibit its use.

Chapter XXI—Disposal of Very Small Amounts of Toxic Solid Wastes

254. There are innumerable instances of very small quantities of toxic solid materials which have become of no further use to their owners, who therefore wish to dispose of them. Not many of them, perhaps, could be described as being from "chemical and allied industries", and we could justifiably be excused from discussing them. But the danger of a toxic waste depends on what it is and where it is rather than where it originates, and in the absence (so far as we are aware) of any other general statement about them it may be appropriate for us to make one.

255. These innumerable instances include laboratories with a few pounds of surplus poisonous chemicals now and again, farmers and smallholders with empty pesticide containers which still contain a toxic residue, gardeners with half-used tins and packets of pesticides they have no further interest in, and householders with similar wastes together with half-empty bottles of pills and medicines which are no longer needed. Sometimes such wastes present no problem, occasionally they may give rise to difficulty, sometimes advice is given on the container as to how to dispose of surplus material (and when it is it should be followed), but we suspect that in many cases there is an uneasy uncertainty in the minds of many people with a social conscience as to whether they would be doing wrong by disposing of these wastes in the obvious ways, or making an unnecessary fuss if they enquired what they should do. It is our hope that this brief note will help to resolve such uncertainties.

256. Where there exists a tip for industrial waste, including toxic waste, which receives thousands of tons per annum and has given no trouble over many years, it may be safely assumed that a few pounds of almost anything can be disposed of there satisfactorily provided it is, if necessary, permanently covered. It is not therefore surprising that some waste disposal contractors who operate on a large scale offer a service for the disposal of small amounts of toxic wastes. Those who have such waste to dispose of may take it that the way of disposal offered by such firms, particularly if it is known that they have access to professional advice, is much more likely to be safe than tipping on a site of their own choosing. They could feel equally sure, if not more so, where the service is offered by a local authority, as it sometimes is. An example is the Great London Council. It should go without saying that the owner of the waste ought to inform the contractor or local authority of the nature of the waste in question, and communicate to them any knowledge he may have about its properties which may not be generally appreciated. The contractor or local authority should not hesitate to take expert

advice himself on such problems where necessary, and for small quantities of embarrassing waste the extra cost of a "safer than safe" method of disposal might well be justified.

257. Surplus small quantities of pesticides should be incinerated where practicable. At the same time, it may be useful to point out that their normal use on the land is a process of disposal, and if they have been approved for use in that way then they have been approved for disposal in that way. If unwanted small quantities of pesticides cannot be burnt or applied to the land as in use, then in many cases they could be tipped with domestic refuse provided the tip is a sizeable one, properly located, properly operated, and receives a fair amount of refuse. There would appear to be no reason why householders should not accept this method for the sort of quantities likely to arise in connection with domestic gardens, but special permission might be necessary in the case of surplus from farms, smallholdings, and very large gardens, and it ought to be made certain that toxic materials from these sources are disposed of to a large tip or an incinerator.

258. Surplus drugs and pills in the average household can be safely disposed of in the obvious way by flushing down the W.C. Many of them are not toxic at all, and those that are will usually be diluted to infinitesimal concentrations in the sewage effluent of the district. The exceptional case could be when the sewage of the district is small in volume (indeed, it could be from one house only) and an accumulation of unused drugs is disposed of at one time. It is just possible then that there might be some toxic effect on a small stream or on land through which the effluent drains. Disposal via dustbin would avoid even this, and it might be preferable (indeed, we have suggested it for surplus household quantities of pesticides) apart from the possibility of carelessness resulting in drugs or pills getting into the hands of children; this is a risk that should not be taken. Where local provision is made for surplus medicines to be returned to the pharmacist for collection and disposal by the local authority it is clearly wise for the public to take advantage of it.

Chapter XXII—Investigation and Research

259. Investigations and researches of one kind or another on liquid industrial waste treatment and disposal have been carried out at least over the last half-century. They have included studies of many wastes, both toxic and merely polluting, and embraced every aspect of the problem from ways in which the waste arises and methods of reducing its original toxicity and polluting character to treatment both by itself and with other liquid wastes of the district, and the effect of the wastes on rivers, lakes and water resources generally. Studies of air pollution from disposal of waste have been carried out over an even longer period, a century at least. There has also been a great deal of research into the disposal of solid house refuse, though until recently not much on the water pollution aspect of the problem; but there has been very little research on the water pollution aspect of the disposal of solid toxic wastes. This is no doubt because pollution due to them has been so infrequent. We feel the lack of this research, and shall recommend that some should be initiated. Until more is known it will not be possible to operate any disposal scheme in the optimum way; either the precautions taken will be insufficient and pollution and other troubles will result, or they will be unnecessarily costly and to that extent a waste of money. The research should certainly include methods of treatment to reduce or eliminate toxicity, but at first it would seem to be more profitable to concentrate on studying disposal by tipping and its effects, since this is both the most popular and cheapest method of disposal and, come what may, is likely to be widely practised for many years yet.

260. Knowledge is, of course, gained by experience as well as by experiment, and it is important that we should make the best use of present experience. We think that there is a considerable place for investigation of what is really happening at those tips, or at least some of them, which have been in use for a long time for toxic wastes and have so far been safe in the sense that nearby water sources or watercourses have not been affected by them. Fears are sometimes expressed that they may be affected in due course, but no one knows. There is no point in not knowing. It would not be difficult or too expensive to construct boreholes downstream of the tip, say 10, 50, 250 and 1,000 yards from its boundary, and ascertain periodically by analysis if and by how much the groundwater at those points has been affected. It might, in fact, be useful to carry out such observations on all sizeable tips set up in future in positions where water could conceivably be contaminated. This would not directly increase the safety of tipping, but indirectly it would increase the safety of neighbouring water supplies from the effects of tipping by giving early warning that pollution was on the way and

thus permitting action to be taken to anticipate the pollution before it had reached the abstraction point.

261. Such investigations would need to be carefully planned and interpreted, for it would be easy to waste a good deal of money on them. It would appear that most of this work should be done by or at the expense of tip operators, municipal or private, and they could recoup it from the charges for waste disposal. They would, however, find it essential to seek the advice of both the water and river authorities and to discuss with them in full both the planning and interpretation. Nor would there be any need for secrecy from the main producers of the waste disposed of; the information they could give (or could reasonably be asked to obtain) could be very helpful in the interpretation of the work. The whole thing should be a co-operative and well co-ordinated enterprise, and the results could have wider application than the site investigated. For instance, such an investigation at one site on the effectiveness of a particular precaution in tipping could give results of general applicability.

262. Such work might far more than pay for itself. In addition to giving early warning of pollution and thus preventing damage, investigation of the movement of percolate and its self-purification during the early stages of tip operation might show the site to be a good deal safer than had been thought, and greater and better use could therefore be made of it.

263. There are also we believe gaps in our knowledge which only experimental work can fill. It is not easy, however, to say precisely what is needed or how it can best be done, or how much it is likely to achieve. This is due to the heterogeneous nature of almost all the factors involved. It is not easy to get a true sample of a solid toxic waste, nor is its analysis a simple and straightforward affair. Its behaviour in a tip—how rapidly it will dissolve, whether it will be permeable to water, etc.—will depend upon its particle size, degree of compaction it receives, whether it has been mixed with other wastes, and so on. After the percolate has reached the sub-soil its behaviour will depend upon the composition of the rock, its structure, permeability, etc., all of which are variable. All this makes the design of experiments more difficult, and the problems which experimental work could be expected to solve have not yet been sufficiently identified. This is one of the matters which will only become clear when the experiments have got under way, and the uncertainty is therefore a reason for beginning experimentation rather than delaying it. We are sure, however, that it would be of particular value to carry out some experiments on the percolation of oily wastes through natural media and other tipped wastes.

264. We think that, because of their wide experience in pollution problems and their equally wide knowledge of industrial wastes, the Water Pollution Research Laboratory of the Ministry of Technology is eminently suited to do this experimental work, and also to take part in the general oversight of investigations made at tips. If they were permitted to expand so as to accommodate a team of, say, 3 to work on toxic solid waste disposal, we believe that after 5 years or so it would be realised how necessary and valuable it had been.

265. One way in which knowledge of the dangers of liquid wastes has been gained has been by experience of cases where disposal has resulted in pollution of rivers, the death of fish, and offence to eye and nose. When this has happened the cause and effect have usually been sufficiently close together in time and

place for the one to be matched with the other with confidence. We do not advocate this method of gaining knowledge, but when such events do take place advantage should be taken of the facts that can be elucidated. Fortunately, the number of cases of gross pollution from toxic solid wastes has been small, but when it happens it is much more difficult to associate the pollution with the waste which must have caused it, largely because of the time interval between disposal and pollution. In the absence of records, however, it is not merely difficult it becomes impossible. We believe, therefore, that suitable records should be kept of what is tipped, how much, where from, and its description or composition. We mention this in a chapter on investigation and research because its existence may add to general knowledge when such happenings do take place.

Chapter XXIII—A Discussion on Safety and Economics

266. In all, the amount of waste which mankind has to dispose of is in the long term virtually equal to the amount of raw material he uses. When we have finished with our clothing, our houses and our motor cars and they must be disposed of, they weigh almost as much as they did when new, and when they do not the part that has worn away has become waste at an earlier stage. Even our bodies, so slowly built up over the years, must eventually be disposed of.

267. The truth of the statement that raw materials equals waste demands that each side of the equation should include what is invisible as well as what is visible. Thus, the raw materials we use must include the oxygen of the atmosphere we breathe and use in combustion processes, and the nitrogen used for fertiliser manufacture. Similarly, the waste must include the carbon dioxide we breathe out and that produced in combustion, and the nitrogen produced in de-nitrification processes. It is the fact that the weight of carbon dioxide produced greatly exceeds the weight of oxygen consumed that accounts for our waste apparently being less than our raw materials—most of the weight of coal and oil used "goes up in smoke", or at least, in products of combustion, and therefore needs special transport before use but not after use. But it is waste just the same, and contributes to air pollution.

268. The equality of raw materials and waste is emphasised here for two reasons. The first is that it makes it obvious—painfully obvious, perhaps, but nevertheless obvious—that it would be quite unreasonable to accept as inevitable that raw materials, their transport and processing should cost a great deal of money and effort, while at the same time to expect that waste and its transport and processing should cost nothing at all. Proper waste disposal must cost money, and we must not be surprised if it costs a great deal.

269. The second point, we think, follows. In dealing with our raw materials economics has a lot to say. In our private lives this is said relatively simply—we cannot afford both this and that, we will have this; we cannot afford the best quality of this, we will manage with the second quality; it is out of the question to have this now, we shall have to wait a couple of years; and so on. In business and public life similar decisions are made, but only after a more scientific analysis of all the factors—we cannot afford to make the whole article of stainless steel, we will use it only for a few special parts because we believe that corrosion of the rest will be acceptable at the price; we will not use this quality raw material for that purpose, because the second best is so much cheaper and it seems that certain precautions will go a long way towards overcoming their

deficiency; it is out of the question to put these attractive additions or those safety devices into our product now, it will never sell at the necessary increased price, we will have to wait a couple of years; and so on. It is our view that similar considerations must of necessity be taken into account in relation to wastes. To admit them for raw materials and reject them for wastes is unreasonable, illogical, and in the long run even impossible. Any useful policy regarding waste disposal must have regard to economics; we must not expect to provide ideal or perfect methods of waste disposal any more than we expect the things which we use to be always ideal and perfect.

270. This is, however, no reason why the ideal should not be defined; indeed, such a definition might well help to decide that which, though short of the ideal, is nevertheless acceptable in the circumstances of a case.

271. So far as water is concerned, both drinking water and river water, the ideal would clearly be that the water should never contain, even to the slightest degree, any constituent extracted from a waste, whether toxic or non-toxic and whether solid or liquid. For river water it has long been accepted that it is impracticable to ensure this, and many of our rivers do contain constituents of liquid wastes, human, agricultural and industrial, which are either irremovable by known methods or have not been entirely removed by treatment before the effluents are discharged. These discharges are subject to the control of the river authorities, who limit the permissible quantities and concentrations of contaminants so that, in the case of rivers used as a source of water supply, normal full treatment after abstraction is sufficient to produce a wholesome drinking water.

272. It is easy to see that the policy regarding contamination of rivers with the constituents of solid wastes (by drainage from tips) should be in line with that applying to liquid wastes. It would be indefensible to recommend idealism in the one case and realism in the other. Nevertheless, because the extent of possible pollution from tips of solid waste is both difficult to forecast and (should the forecast be wrong) difficult to remedy, one would expect a realistic policy for solid wastes to be nearer the ideal than it is for liquid wastes. There would be a greater need to play for safety so as to allow for the uncertainties in the situation, but it should be possible to allow activities which, within permitted limits, could not, even if the worst came to the worst, result in the water supply after treatment failing to reach accepted standards.

273. When underground water is at risk a practical policy is even more difficult to work out because, should undesirable contamination occur, there is no ready means of either stopping the pollution or treating the water. The source might therefore have to be taken out of service, perhaps for a very long time. This could sometimes be done at a cost, and since this chapter brings in economics it may be added that the cost of doing this should be one of the factors taken account of in weighing up the full situation. There have, in fact, been cases where wells or springs supplying isolated houses near a tip have been polluted and replaced by mains supplies. Provided the cost of replacement falls where it should, this seems a very proper thing to do. Indeed, in some cases it would be wise to replace such supplies in anticipation of their being polluted sooner or later and using the sources only as sampling points to ascertain the progress of the expected pollution. Economically this may be very sound.

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274. With larger sources less risk of pollution could be taken, because replacement would not only be much more expensive but often almost out of the question for lack of alternative sources. But because a source is larger, it requires more material to contaminate it to a given degree, and this is a point to be borne in mind. We think that working policy regarding tipping where sizeable underground supplies are at risk should include at least some of the following precautions to counter that risk (in addition, of course, to precautions taken for other reasons): (1) adopt measures to prevent or reduce percolation; (2) exclude from tipping very toxic substances if they are readily soluble; (3) limit the amount of tipping and the area covered so that the percolate, when diluted to the extent necessary to make up the yield of the source at risk, would not, even in the worst case, produce concentrations of toxic matter greater than permitted in drinking water by the World Health Organisation or other authorities; (4) sample from test boreholes to ascertain if toxic matter is in fact travelling in the ground; (5) take advantage of special knowledge of either a waste or a tip; for example a waste proved to be biologically oxidisable could be tipped when it could be unsafe to tip a resistant one, and a tip which had been proved safe was preferable to one which only appeared safe.

275. It could, however, be argued that the problem of toxic solid waste disposal is sufficiently small to permit a policy of idealism rather than realism even though this would be impracticable for other wastes. We have previously concluded that the weight of indisputably toxic waste is only a very small fraction of that of all industrial waste. The present cost of disposing of it, though large for some firms and running into millions of pounds per annum, is on the national scale nevertheless a comparatively modest one.

276. It might appear that for these small quantities, because of their danger, perfection (meaning perfect safety) in its disposal can reasonably be demanded. But this is to ignore the fact that the dividing line between indisputably toxic wastes and less toxic and non-toxic wastes is purely arbitrary and may well vary widely with circumstances, and that almost every waste has its dangers in disposal. Even inert wastes like ashes may contain traces of, for instance, arsenic, which could theoretically contaminate water as much as a small quantity of arsenical waste. Even inert wastes like calcium sulphate could add hardness to a water to such an extent that it would be damaged to a greater degree than it would if, say, 1 mg/l of zinc were added to it. Idealism for all wastes is impossible, as has been stated; a selection of certain toxic wastes for disposal in an ideal way as a matter of necessity irrespective of economics would still leave others which could be toxic after disposal however the selection were made. The law of diminishing returns applies to safety in waste disposal as to many other things, and there comes a stage when the extra safety bought by the expenditure of an extra £1 sterling on disposing of a toxic waste is less than if it were spent on a waste which is not so fundamentally toxic.

277. This is not to say, of course, that when absolute safety can be purchased at a reasonable price, and sometimes it can, it should not be so purchased. It should.

278. We are encouraged to take economics into consideration, even in matters of health and safety, because it is done, not always openly, in all other aspects of life. We could make our roads safer if we were prepared to pay the price; our cars could be less vulnerable, at a cost; we could make it more difficult for

people to fall into rivers and be drowned; we could reduce the number of cases of electrocution, safety in daily work could be improved; and so on: all at a price. We do, of course, make progress, but no one supposes that in any of these cases we will reach perfection. We are apt to say that we go as far as reasonably practicable, or even as far as possible (though we rarely mean that literally), but what we are really saying is that we are not prepared to pay the necessary price to go further than we do. We take economics into account. So, in considering our own problem we candidly affirm that we are taking economics into consideration. There is a price too big to pay for perfect safety in toxic waste disposal. We do not pretend that if our report is accepted and acted upon then there will never be a case of water pollution from toxic solid waste. Our aim is more limited than this; it is practicable, and in our view it will achieve more (not less) than would a more idealistic aim. We believe that, without trying to be quantitative, what we shall recommend will make the disposal of toxic waste much safer and satisfactory than it is now, and will give manufacturers better facilities than they have now, and will not cost a great deal more than at present. At the same time we wish to encourage manufacturers and others to put greater effort into developing better methods of disposal than are known at present.

Chapter XXIV—Ways of Improving Present Technical Practice in the Interests of Safety

279. The contents of this chapter largely arise automatically from the discussions in, or are repetitions of conclusions already reached in, previous chapters. They therefore need to be stated only briefly; but it is advantageous to collect them together into a coherent whole, as they comprise the technical policy we would recommend in fulfilment of the aim as expressed at the end of the preceding chapter.

280. Firstly, we would make the point that there are some wastes so specific, both in their production and in the hazards attached to them, that they merit special and individual consideration. This is best done by groups of people, including experts from the industry producing them. We have in mind, for instance, asbestos wastes, which have lately been the subject of concern. Recently (September 1969), the Asbestos Research Council issued a "Recommended Code of Practice for the Handling and Disposal of Asbestos Waste Materials". Another special waste is sludge from tanks of "leaded" petrol. Advice on the treatment and safe disposal of this is contained in a booklet on tank cleaning issued by Associated Octel Company in 1965. We have not thought it necessary to consider such problems which require specialised knowledge to advise upon, and would emphasise that our general recommendations must not be taken as superseding those made for such specialised wastes. At the same time, we do not recommend that such wastes should be excluded from the proposed general law about solid waste disposal, which we discuss later.

281. We would like more attention to be given to methods of avoiding or reducing the quantity of waste, particularly of course, toxic waste. This would have the double advantage of conserving raw materials and easing the problem of disposal. Looked at nationally and in the long term both these advantages have merit, even though economics may not in some instances favour them. Clearly economics must come into the question, as we have been at pains to point out, but it need not, and in our opinion should not, constitute the whole story.

282. There are several methods of reducing waste or reducing the quantity of toxic waste; but we would like to emphasise the possibility of reclamation of useful materials. We have not been able to go into detail about this, but we feel particularly that more attention should be given to the possibilities of reclamation of oil from oily wastes because these can be particularly difficult to dispose of without nuisance. We understand that there are firms prepared to collect certain wastes for recovery, and we think that producers of these wastes should make more use of these facilities even though strictly it may not pay them to do

so. There could also be a place in a waste disposal contractor's business for a recovery centre.

283. Given the inevitability of the production of toxic wastes, the ideal way of disposing of them is to destroy their toxicity before abandoning them. If the material is organic this can be done by incineration. Even if the waste itself is non-flammable, passage through an incinerator burning other waste, or even burning special fuel in order to deal with the toxic waste, will break it down into combustion gases which can be allowed to escape or be readily treated. Thus, toxic DDT produces no more dangerous products than does non-toxic PVC. Incineration will not deal with all toxic wastes, facilities for it may be too remote to be used economically, or there may be some other good reason in any particular case why it should not be insisted upon. Nevertheless, more use should be made of incineration than now takes place.

284. In particular, we see no reason why a greater use should not be made of incinerators whose primary job is to deal with house refuse. There are, of course, limits to this if their main job is to be continued to be done efficiently, and, of course, corrosion and similar troubles should not be risked.

285. The toxicity of some wastes can be destroyed by chemical treatment, e.g. cyanide can be destroyed by chlorine, and strong acids can be neutralised.

286. Some toxic materials can be destroyed biologically. If this can be done before they are abandoned disposal must be safe, but the process may be expensive and destruction is not usually complete. Often, however, such a waste can be abandoned in such a way as to be exposed to biological agencies for long periods before the toxic material can travel very far towards a place where it can do harm. If, at the same time, a good deal of dispersion can be guaranteed, then destruction and dispersion together should constitute satisfactory disposal.

287. Sometimes dispersion itself may reduce the concentration of toxic matter tipped below a level at which harm can be done so that, if it can be guaranteed that no re-concentration processes exist, it becomes in itself safe disposal.

288. For both the above reasons disposal to sea, with or without sewage sludge, sometimes to very deep sea depending on the degree of toxicity, and widespread dispersal on land, may be satisfactory for some wastes.

289. A toxic waste is also satisfactorily disposed of if it is put permanently out of the way. For instance, it could be discharged to a deep underground cavern (a natural one or a disused mine) surrounded by impermeable rocks. There are few such places, and we would like to see them reserved for really dangerous toxic wastes. Incorporation of wastes in concrete which is then thrown overboard at sea may also be necessary and suitable in a few cases.

290. The more common method of tipping is not demonstrably as safe as any of the above. Frequently it partakes of the character to a partial extent only (as far as safety is concerned) of more than one of the above methods. In most tips, for instance, a solid toxic waste is put out of the way for a long time, though usually not permanently; there is often ample opportunity for biological breakdown if that is possible; and the rate at which toxic material will arrive at a point of possible nuisance is such that dilution is likely to have been very large.

291. Sometimes, however, this method of disposal fails and some pollution occurs. The proportion of failure has so far been small, and serious problems have arisen only very rarely. But there is room for improvement and we are seeking this.

292. In particular, we would refer again to what we have said in Chapter XXIII about the monitoring of aquifers which could conceivably be affected by matter percolating from tips containing toxic or polluting wastes. This should be much more widely adopted as a routine; it is much better to obtain advance information that pollution is (or is not) on the way than to remain in ignorance until it has actually reached a supply source and caused a complaint to be made.

293. In so far as toxic waste is reclaimed or burnt or otherwise destroyed, or dispersed in the sea, or placed in deep impermeable mines, then the amount for disposal on tips is reduced and the trouble resulting from tipping should be reduced too. In so far as the waste selected for incineration, deep burial, etc., is more toxic than the average toxic waste, then the reduction in trouble from tips should be proportionately greater than the reduction in quantity tipped. This is what we would aim for. The "specialised" methods of disposal, in so far as they are of limited capacity, should be reserved for the most toxic wastes.

294. We have little to say about the selection of tip sites. Since planning permission became necessary and full account was taken of representations of the water authorities and, more recently, the river authorities, the sites have, so far as we know, been chosen wisely. In so far as they are intended for one waste only —pulverised fuel ash, spoil from china clay mining—then planning permission can fully control their use. But if they are intended for a variety of wastes, including wastes of all degrees of toxicity, solubility and degradability, then it is impossible for planning consent to control the operation satisfactorily. It might indeed be better if it did not try, leaving all detailed decisions to be made by a specialist with full and growing knowledge of the site as experience is gained in its use.

295. It is indeed our view that discharges of toxic wastes to tips should not be made without authorisation. Before this is given, information should be obtained on both quantity and composition of the waste and where it comes from, and the authorisation itself should be the result of a technical decision based on knowledge of both the waste and the tip site and environment. A record of what is discharged should be kept permanently.

296. It would add to the safety of tipping if (when necessary) some knowledgeable person or authority should decide not to put a waste on this tip because of its danger but on that tip, where it is far less dangerous; if he could decide that a particular tip should be waterproofed with clay so as to be able to accept particularly toxic wastes, whereas another one should not and therefore be limited to not very toxic waste; if he could segregate certain wastes to a particular part of the tip which could later be given a waterproof cover; if he could so tip certain wastes that percolate could be deflected from it by other means; and so on. In other words, good and knowledgeable tip operation could add a great deal to its safety, and it ought to be provided.

297. We have already suggested (Chapter XII) that in the interests of groundwater protection, consideration must be given to the establishment of some tipping sites wholly above the surrounding ground level.

298. Disposal of toxic wastes would be safer if aqueous wastes (except limited quantities of aqueous sludges) were not disposed of on tips. On some fortunately situated tips it appears to be safe enough, but on others it should be discouraged or prohibited, except where evidence can be produced that it is most likely to be satisfactory and that no better method is reasonably available.

299. There should also be discouragement of disposal of oily wastes by tipping. Again, this need not mean prohibition, nor even limitation for certain tips, but a tendency towards tipping in deep, dry mines would appear desirable.

300. There should also be encouragement, sometimes instruction, to construct test boreholes to ascertain the progress, if any, of pollution from certain tips, and to carry out periodic analyses as may be agreed with the water and river authorities.

301. It would certainly also be an advantage if the person or authority who takes the sort of decisions referred to in the previous paragraphs were sufficiently closely concerned with other possible methods of disposal (mineshafts, incinerators, to sea and so on) to be able to advise, or even direct, that certain wastes should be disposed of in those ways rather than to tips at all.

302. In our view, if such a policy were operated by a person or authority with knowledge, understanding, integrity and without financial interest in the decision, disposal of toxic solid wastes would be a great deal safer than it is now. There could still be cases of pollution, as has been previously pointed out, but the occasional one should not condemn either the system or the man or authority who had, in good faith and on the best evidence available at the time, made the decision which the occurrence of pollution proved to have been wrong.

303. It now remains for us to consider who that person or authority should be and what changes in administrative arrangements or in law would be required in order to establish the system of control described.

Chapter XXV—The Authorising of Toxic Waste Disposal

304. It is obvious that in every instance of a toxic solid waste arising someone must say how it is to be disposed of. If it were possible to produce a set of rules which would cover all eventualities, then anyone who could read and be trusted to follow instructions would presumably be competent to make the necessary decision. It should be plain from what we have said earlier that we do not think it possible to produce such a set of rules. Although certain general principles apply (and we have already discussed these) the decision in any one case should also take into account all the local circumstances—the exact nature or composition of the waste, its quantity, what facilities are available within reasonable reach, what risks are attached to each, and so on. This, in our view, could only be done by a person or authority who has sufficient knowledge of industry, geology, rivers and water supplies, who knows the locality in detail, who has access to a number of different ways of disposal so that he can select the most suitable, and who has no financial interest in the decision. The last qualification is, in our view, necessary as giving the best possible assurance of impartiality. If all this be accepted, it is not difficult to see how the various authorities concerned with toxic waste disposal measure up to the requirements.

305. First, it seems plain that the authorising body or person should not be a manufacturer or even an association of manufacturers. Their primary interest in waste disposal is financial, and it is no criticism of their sense of responsibility to suggest that questions of safety of water supply, particularly long term safety, might not be given the weight they deserve. Moreover, most manufacturers would not have the expertise available to allow them to make a proper judgment, and it may be said that there is no better case for allowing manufacturers to make the final decision on where their solid wastes should go than there is for allowing them to decide finally where their liquid wastes should go and what treatment should be given. It may be accepted that there is no worse case either; for instance, just as a manufacturer has the right to discharge normal surface drainage to sewers because it is similar to domestic surface drainage so, if he produces solid wastes (waste paper, ashes, etc.), which are similar to house refuse, then they should need no more special authorisation than does house refuse, the disposal of which is the subject of a parallel study.

306. There is even less justification for allowing a waste collector or carrier, as distinct from a tip operator, to decide the place or method of disposal. He does not have complete knowledge of the waste on the one hand nor of the risks of disposal on the other.

307. The commercial tip operator should know what is happening on his tip and of any risks involved. If he is a responsible man he makes himself fully aware of the general risks, including fire, explosion, dangers consequent upon trespass and so on, and takes precautions against them. He should also be aware in a general way of the dangers, including long term ones, to water supplies and rivers. But he is not normally expert in these matters, nor do we think he has often attempted to check the safety of his tips from this angle while they are being operated. Mention has been made earlier of borings near certain tips to ascertain if pollution is "on the way", but in practice this has rarely been done and perhaps hardly ever without prodding by some external authority. We do not blame the tip operator for this; he may well be in competition with others and might not therefore be able to increase his charges, so that any such investigation would have to be entirely out of profits and not therefore to be incurred unless demonstrably needed. We do believe that a great deal can be done to promote safety by the tip operator, and more still if an operator has a choice of tips which he can operate in an optimum way. But his main interest is still financial. To refuse a waste is to refuse a source of income. Moreover, his knowledge of industry may be too limited. We do not therefore think that the tip operator should himself have the final say in the method by which specific toxic wastes should be disposed of.

308. We should add at this point that, just as our comments about manufacturers included associations of manufacturers, so do our comments on waste collectors as such and on commercial tip operators include any associations of them.

309. From what has been said earlier it is clear that the river authorities should have an important say in whether and where toxic wastes should be tipped. River or underground water pollution is almost always a theoretical possibility unless suitable precautions are taken, and the river authority's views must always be taken into full consideration even though their consent is not legally necessary. But it may be argued that although they have no financial interest in the decision they may nevertheless not be impartial, since their sole interest relating to waste disposal is the protection of water quality. Certainly they have no expertise on such matters as waste incineration and disposal to sea, and for these reasons we cannot recommend that they should be given the final say on how specific toxic wastes should be disposed of.

310. What has just been said about river authorities applies in even larger measure to water authorities, whose interests in this respect are confined to water and who are not directly concerned with waste disposal of any kind.

311. This brings us to the various local authorities who have a vital interest in, and at least some degree of control over, what is happening in their areas. Most of them have not only an interest but a duty in relation to waste disposal, though not specifically toxic waste disposal. They have naturally also a detailed knowledge of their areas.

312. In England and Wales the rural districts together comprise the greater part of the area of the country, they contain the majority of suitable tipping sites (at least, in the views of people who want to use them) and usually they are refuse disposal authorities. A few of them have toxic waste disposal problems, and appear to manage them with competence. But although many might have a

selection of tips of differing degrees of safety from which to select one suitable for particular wastes, few of them would have incinerators as well. Moreover, there are too many of them and their financial resources are usually too slender to permit of hope that they could each employ an officer sufficiently well and widely qualified to advise with confidence on where specific wastes should go. We would not suggest that this duty be given to the rural district councils.

313. Still less would we think that the duty should be given to the urban district councils. They are generally of very much smaller area, the sites in each area would be much more limited in numbers, few of them would have a choice of sites in their areas, and they could not be expected to employ the necessary highly qualified staff. Neither, we believe, could municipal boroughs generally, even though on the average they are richer than urban districts. Moreover, they are often just as limited in facilities for disposal.

314. County boroughs, however, are somewhat different. They are sometimes rich enough, and their problems great enough, to justify the appointment of specialist staff, and if they had to authorise or undertake toxic waste disposal some of them could afford to employ experts with the wide and unusual variety of knowledge necessary. But this is probably true only of a minority of them; several, for instance, have a population of over ½ m. But 30 out of 77 are under 100,000, and one is below 40,000. We cannot think that these latter would have the resources to engage specialist staff or possess the necessary kinds of facilities to be able to decide upon the disposal of toxic wastes.

315. One thing common to the types of local authority so far discussed is that they are all refuse disposal authorities; a common disadvantage (with a few exceptions) is that they are too small. The converse of both these is true of the remaining type of local authority—county councils. They are not refuse disposal authorities, but their areas are much larger and often more populous than the others. They could hardly be made toxic waste disposal authorities, but could be empowered to authorise toxic waste disposal. In fact, in at least some cases they undertake duties very similar to those of an authorising body under local Acts of Parliament, e.g. Buckinghamshire, Essex, Hertfordshire and Surrey. Their powers are somewhat limited; they are directly concerned only with tipping; they do not have jurisdiction in any county boroughs in the counties; and they cannot say that a particular refuse shall be tipped in a particular place, only that it may be if the recipient authority also agrees. We do not deny that, at least when the Acts were passed, these were very proper limitations.

316. This appears to be an appropriate place to refer to an authority which is unique and very large, the Greater London Council. It may be described as the first regional authority to be set up in this country, though it will presumably be the fore-runner of some others (see para. 319). From our angle its uniqueness stems from its being at the same time (a) very large, not so much in area as in population and financial resources, (b) the refuse disposal authority for the whole area, though not the refuse collection authority, and (c) the sewage disposal authority for the greater part of the area. It is therefore well staffed with people highly qualified in refuse disposal and effluent treatment, including chemists who should have a good general knowledge of the chemical industry. Because it is the sewage disposal authority it already has dealings about waste

with most firms producing it, and also can ensure that the capacity of the sewage treatment works to deal with toxic liquid wastes is properly utilised. It also discharges vast quantities of digested sewage sludge at sea, and is in a position to use the vessels for the carriage of such toxic wastes as may be difficult to dispose of in other ways but shown to be suitable for disposal at sea. Because it is the refuse disposal authority it has access, either because it owns them or is associated with them, to methods of solid waste disposal with different types and degrees of risk; these include tips in very different surroundings, and incinerators. If it were invited to deal with toxic wastes it would therefore have a number of options at its disposal and expert judgment in its service, and the likelihood is that as a result disposal could be accomplished safely and satisfactorily. Because of the large scale on which it works it would probably find it easy to dispose of limited quantities of toxic waste with house refuse.

317. Of course, the scope of possible action by the Greater London Council is circumscribed by a number of factors which would be common to any authority of this kind, and by others which may be specific to them. They must, of course, conform with conditions laid down by local planning authorities, and treat sewage so that the effluent is within the limits of quality laid down by the pollution prevention authorities. They must also have full regard to the views of those authorities concerned with the effect of tips on rivers and other water sources. Furthermore, tipping sites are often in private ownership and outside the administrative area of the Council, and consent to tip there would clearly be necessary from the owners and maybe from other local authorities. However, in this chapter we are seeking to discover what sort of authority could undertake the duty of authorising a place and method of toxic waste disposal so that it would be both proper and safe disposal, and we must assume that other difficulties can be surmounted. We believe that the Greater London Council could do this, because it is large enough to have (and, indeed, has) expert advice, because it should be impartial, and because it could and should be helpful to waste producers by virtue of the facilities for disposal available to it. We understand that the Director of Public Health Engineering of the Council has set up a Working Party to investigate the problem of industrial sludges and toxic wastes in the area, and that they will consider what contribution the Council can make to assist in dealing with the situation.

318. We had arrived at this stage in our deliberations when the Redcliffe-Maud Report on Local Government in England was published. At the same time, it was indicated that the Government accepted its proposals in principle. More recently a White Paper (Reform of Local Government in England, Cmnd. 4276, February 1970) has been published, which proposes some modifications to the Redcliffe-Maud scheme, and what is said in the next few paragraphs takes these into account. It certainly appears justifiable for us to assume that the pattern of local government in England which has existed for so long, and on which the earlier part of this chapter is based, will be radically changed within the next few years. Our recommendations on organisation should therefore be in accordance with the proposed new pattern. This does not mean that what we have said earlier about existing local authorities is now useless, since the old organisation may be with us for a few years yet. It will be best, we think, if our main recommendations assume the new set-up, and if we add, more briefly, what we could substitute for them until it becomes effective.

319. In the first place 5 metropolitan areas, centred on Birmingham, Manchester, Liverpool, West Yorkshire and South Hampshire, and comparable in size with Greater London, will be set up, and will be organised in a way similar in several respects to Greater London, namely with two levels of authority, each having a single metropolitan authority and several metropolitan district councils. The important point from our angle is that the metropolitan authority will be responsible for refuse disposal, as is the GLC, for the whole area, and the district councils for refuse collection, as are the London boroughs.

320. It would appear to follow that the metropolitan authorities would be in a position very similar to that of the Greater London Council and be able to offer to industry methods of toxic waste disposal just as is the Greater London Council. We have spoken earlier, with satisfaction, about that, and we are equally confident about the new metropolitan authorities. They are large enough (though not as populous as Greater London) and rich enough in rateable value (though much poorer than Greater London) to have available a wide selection of disposal methods and sites and to employ highly qualified experts to give sound advice. We think they should be the authorities with the duty of authorising methods of disposal of toxic solid waste produced and disposed of in their areas. The exact limits of their authority, powers and responsibilities will be considered later. Because these metropolitan authorities are to be refuse disposal authorities, we would expect that they would not only authorise disposal of toxic wastes but in many cases provide and operate the necessary facilities.

321. The remainder of England will be divided into 51 "unitary areas", each comprising both town and country and each with one level only of local government. On average, the areas of these will not be far from that of the average present county, but the variation will be at least as great as occurs at present, i.e. by a factor greater than 20. The population will vary much less, by a factor of about 5, the median being rather less than 1m. These areas, too, will be refuse disposal authorities, and we do not doubt that the largest will be almost as capable as the metropolitan authorities of authorising toxic waste disposal and themselves disposing of at least a proportion of it. But the majority of the unitary areas, in our opinion, would not unaided be able to provide the necessary variety in facilities for disposal, nor the necessary calibre of expert advice.

322. The new local government areas which the Redcliffe-Maud Report proposes, together with the present Greater London Council, will be grouped into 8 larger units, or provinces, each with its own council. The recent White Paper, however, states that conclusions about them are being deferred. The key functions of these councils would be to settle provincial strategy in planning and other matters within which the unitary authorities would then operate. The areas of all these provinces should embrace a wide variety of methods and sites of waste disposal, and they would be rich enough to be able to appoint highly qualified specialist advisory officers. However, the function of a provincial council would be concerned primarily with broad strategy and planning, and the case by case authorising of toxic waste disposal does not seem to fit well with the general idea of the councils. More important, none of the provincial councils would be a refuse disposal authority, and consequently any specialist adviser engaged by them could not be closely concerned with the actual operation of waste disposal facilities, in particular with the techniques of tipping (and we have seen how this can influence safety) and he could not be as effective as if he

personally supervised the carrying out of his decisions. Nor could he be in such close touch with individual problems, difficulties and investigations, which would play a major part in building up a store of knowledge on the whole subject. On the whole, therefore, although we realise the necessity of having "inspectors" whose duties are apart from day-to-day responsibilities and who are able to advise broadly on developments and to settle disputes, we feel that these should be services of the Central Government rather than of the provincial councils.

323. We have already concluded that Greater London and the 5 new metropolitan authorities would be quite competent to authorise the safe and proper disposal of toxic solid wastes. We have also expressed the opinion that some of the largest of the unitary authorities would be almost equally competent. If we take these to include only the 6 most populous of them, these authorities together would cover half the population of England and, presumably, a good deal of the toxic waste produced. With such a beginning, and having pointed out the disadvantages of making the provincial councils responsible, it seems that we are driven to recommend that the job should be completed by other unitary authorities combining in suitable units and acting together. This is certainly in line with what we would have recommended had we been working *in vacuo*, i.e. without any existing or proposed local boundaries. For instance there is, we understand, a good deal of traffic in toxic wastes between Hertfordshire and Essex, and in view of this and the difference between the two counties—chalk in Hertfordshire and no sea coast, clay in Essex, access to the sea and existence of marshes along the Thames Estuary—we would have concluded that these areas should join together to tackle the whole problem. This is an illustration rather than a recommendation. So we consider that unitary areas could form groups, maybe not more than 2 or 3 in some cases, which could be largely self-contained in the matter of toxic solid waste disposal and which would, in addition, be competent to effect the necessary authorisation. We believe that inter-county and inter-council arrangements for specific purposes are not now unknown, and presume that they will be permissible under the new arrangements. Whether they would be entirely voluntary or brought about by legislation is not a matter of importance to us at the present time.

324. We recommend, therefore, that, in the new organisation proposed by the Redcliffe-Maud Commission, toxic solid wastes (and toxic liquid wastes when disposed of in ways not covered by existing Acts of Parliament) should only be disposed of in accordance with authorisation from the proposed unitary authorities acting singly or in groups, the proposed metropolitan authorities or the Greater London Council as appropriate. In the next chapter we attempt to explain how this might work in practice and to foresee what would be required in the way of legislation and organisation.

325. The recommendation can only come into effect in England when the new local government structure has been brought about.

326. What has been said above about local authorities applies generally to Scotland, except that there all county councils are refuse disposal authorities. For that country the Royal Commission on Local Government under Lord Wheatley (Cmnd. 4150, HMSO September 1969), has recommended a two-tier structure consisting of 7 regional authorities and 37 district authorities. Disposal of refuse is considered by the Commission to be a function appropriate to the

regional authorities, and collection of refuse a function for the district authorities. If Scottish local government is so reorganised, the authorisations which we recommend as prerequisites to disposal of toxic wastes would be most appropriately issued by the 7 regional authorities as the major refuse disposal undertakers in Scotland. It would be, however, for separate Scottish consideration whether a combination of two or more of the regional authorities might be more appropriate in the less industrialised areas of Scotland.

327. Proposals for the reorganisation of local government in Wales were the subject of Cmnd. Paper 3340 published in 1967. More recently it appears that some variations will be made, but it is not for us to say what the final proposals will be. Nevertheless, it appears that South Wales, where most of the toxic wastes are produced, will form either a metropolitan area or several unitary authorities similar to those proposed for England. They should therefore be equally competent to act as authorising bodies for toxic solid waste disposal. With regard to the remainder of Wales, which is largely rural, it should not be difficult to find an arrangement which will work, since the problem will be of quite small dimensions.*

Since the Report was signed there have been further proposals about local government in Wales. It would be in line with these and, I believe, with the views of the Committee, if para. 327 were now reworded as follows:

"Proposals for the re-organisation of local government in Wales were made in the White Paper "Local Government in Wales" (Cmnd. 3340) published in July 1967. Revised proposals for South Wales were contained in the White Paper "Local Government Re-organisation in Glamorgan and Monmouthshire" (Cmnd. 4310) published in March 1970. Under the latest proposals the geographical counties of Glamorgan and Monmouthshire where most of the toxic wastes are produced would be divided into three unitary areas similar to those proposed for England and as competent to act as authorising bodies for toxic solid waste disposal. In the rest of Wales the present two-tier structure would continue, but with much larger authorities at both levels—4 county councils (compared with 11 at present) and 20 district councils (compared with 117 at present). In this largely rural area it should not be difficult to find an arrangement which will work, since the problem will be of quite small dimensions."

A. Key
Chairman

Chapter XXVI—Legal, Organisational and Administrative Requirements

328. Having agreed that there should be an authorising procedure for toxic solid waste disposal it is plain that it would need to be established by legislation. Although we believe that much progress towards it could take place voluntarily, given good will and the promise of legislation, we do not think that any voluntary system would by itself be entirely satisfactory. It remains for us to consider what sort of legislation there should be.

329. The first difficulty is to decide what this legislation should cover. The answer "toxic solid wastes" is clearly not acceptable unless that term can be defined sufficiently precisely, and we have earlier pointed to the difficulty of doing this. Maybe the Acts dealing with poisons generally might help, but we have not sought advice on this point. In any case, we think that the authorising procedure ought to apply to solid wastes which could be highly polluting even though they might be non-toxic. For instance, if a firm wished to dispose of a large quantity of powdered dried milk which for some reason had become waste the dried milk, if tipped on to bare chalk or limestone, might well seriously contaminate underground water and make it undrinkable. The disposal of the waste should be subject to authorisation just as though it were specifically toxic.

330. On the other hand, we have seen that the great bulk of industrial solid waste is claimed to be inert and in fact does not give rise, on disposal, to any of the troubles we have had principally in mind. There does not seem to be any point in subjecting that to the special authorising procedure which we are recommending.

331. From what we have said in an earlier chapter it will be realised that we should want the authorising procedure to cover liquids, both aqueous and tarry, at least when they are tipped and probably the latter when disposed of at sea.

332. There may be several ways of resolving this complex situation. It seems to us, however, that the right way to tackle the problem of definition is to catch everything in the net and then allow to escape all that can safely be permitted to do so, rather than try to catch only that which can be proved potentially harmful. Thus, we think that authorisation for disposal should be necessary for all industrial solid, semi-solid and liquid wastes of whatever origin, nature or composition, excluding however certain industrial wastes which can be precisely defined and which are known to be safely disposable without the necessity of authorisation. For instance, the following possible exclusions come readily to mind and illustrate the grounds upon which an exclusion could be based:

a. All liquid wastes which are disposed of under the Public Health (Drainage of Trade Premises) Act 1937, the Clean Rivers (Estuaries and Tidal Waters) Act 1960, the Public Health Act 1961, the Rivers (Prevention of Pollution) Acts 1951 and 1961, and the Water Resources Act 1963. In Scotland the equivalents are the Rivers (Prevention of Pollution) (Scotland) Acts 1951 and 1965, and, when it comes into force, the Sewerage (Scotland) Act 1968.
b. The segregated solid wastes of canteens and the generally domestic activities of industry, because these can and should be disposed of with house refuse.
c. All ash and clinker from the burning of coal—more and more this is becoming power station ash, for the disposal of which special arrangements are made.
d. All wastes which are incinerated on the firm's premises, provided the processes satisfy the Clean Air Acts and the Alkali Act.
e. Waste produced in the construction of buildings and the demolition of certain classes of buildings, because of its inertness.
f. Sludges from water softening and water treatment.
g. Spoil from mining operations, provided it is disposed of by a method requiring and having obtained planning permission.
h. Farm wastes, when disposed of by the accepted methods of good husbandry.
i. Iron and steel works slag.

Other classes will certainly suggest themselves.

333. If it were found later that certain other wastes were precisely definable and inert then they, too, could be excluded from authorisation, perhaps by Ministerial Order.

334. In practice, we also believe that it would be possible to make the authorisation merely nominal in a large number of cases including, as an example, calcium sulphate sludge which is disposed of in a place so obviously safe as not to merit investigation. Indeed many, perhaps most, existing wastes disposed of by existing methods could be authorised without difficulty.

335. It is one thing to authorise the disposal of a waste in a particular way and in a particular place, but quite another actually to carry out the disposal; and although authorising would be a duty of the body which will also be responsible for refuse disposal in an area (assuming the Redcliffe-Maud proposals come to pass), it is not intended that it should necessarily undertake the disposal of industrial waste, although it might well do so. Disposal may still be carried out by the industrialist who produces the waste or by private contractor. Thus, so far, the authorising body will only have the responsibility of saying that a particular waste disposed of in a particular way at a particular place will be safe in all reasonably foreseeable circumstances. To make this plain we think the legislation, after stating that no wastes (apart from the exempted ones) shall be disposed of without authorisation, should go on to require the producer of the waste to supply to the authorising body particulars of the quantities, nature and composition of the waste, and the proposed method and place of disposal. The method of disposal will thus continue to be primarily the responsibility of the waste producer, and we think he will be glad to have it. He will then be satisfied that the cheapest method which he feels to be satisfactory has at least been considered, because that will be the one he will propose, and the likelihood is

that in many cases it will be authorised. Often the authorisation would be unqualified. Sometimes there could be simple conditions, such as: "tipping must be in a particular corner of the proposed tip", or "the deposit must be covered immediately", or "the top level of the waste must be at least 6 ft. below the intended top level of the tip" and so on. In some cases, of course, more stringent conditions would need to be laid down, or a refusal to authorise would be justified. In many such cases this should be a signal for informal consultations to begin.

336. Actually, it is hoped that (as so often occurs with proposed discharges of liquid wastes to sewers) formal submission for authorisation in respect of all sizeable or difficult cases would only take place after informal discussion had led to agreement and made it virtually certain that authorisation would be given. This can hardly be laid down in legislation, but is certainly a recommended policy. The likelihood would be, we hope, that the authorising body would be able to suggest more acceptable ways of disposal in cases where they had to refuse authorisation, or alternatively suggest possible treatment of the waste so that it could be disposed of as at first proposed. After examination of these the industrialist would then resubmit his application, suitably modified so as to make authorisation possible.

337. Of course, occasionally there would be deadlock, which should be resolved at a higher independent level. We think that, as in the Public Health (Drainage of Trade Premises) Act 1937 and other legislation we have quoted, there should be an appeal to the Minister, whose decision would be final.

338. We have throughout been greatly helped in our consideration of the toxic solid wastes disposal problem by the legislation relating to liquid wastes. Although there are major differences in the problems, as we have pointed out in appropriate places, there is an undoubted similarity, and we believe that a considerable degree of parallelism between the legislative situation relating to each is desirable. When we have considered hypothetical cases of solid waste disposal and the problems of powers, duties, relationships and responsibilities which were likely to arise, we have been impressed with the number of occasions when the Public Health Acts relating to industrial liquid wastes and the Rivers (Prevention of Pollution) Acts appeared to have the answer. We do not think we are required to work all this out in this Report, but we would certainly recommend those whose duty it will be to draft legislation on our Report to do so with those other Acts very much in mind.

339. There is, however, one very important feature of solid industrial waste disposal which is absent from liquid waste disposal by those methods in which the local authority has a part to play. This is the existence in many cases of an intermediary. With liquid waste the local authority accepts it direct from the factory into the sewer, and from there its course to the sewage treatment works and river is pre-determined; there is no question of its going astray. But with solid and semi-solid wastes and liquid wastes that are tipped, or dealt with otherwise than to sewer or river, there must be a carrier from factory to disposal site. This may be the manufacturer or the local authority or a contractor, and in a large number of cases it is a contractor.

340. Now it seems to us that the disposal of toxic solid waste is most likely to go seriously wrong during the collection stage, i.e. while it is on its way from source

to disposal site. We believe that experience supports this view. It is true that a manufacturer may falsely describe his waste, but without the connivance of those who transport the waste the falsehood would be likely to be discovered by the disposal authority and, if suitable penalties were available, such false descriptions could be made the reverse of profitable. It is also true that the disposal authority or the tip operator might accept waste he should not accept, but this would be the tip owner or operator's responsibility; the effects of acceptance would not be very likely to be disastrous and they would recoil on the tip owner or operator when they occurred. But the collector could deposit a dangerous load in such a dangerous place that the result could be very disastrous, and if the place, time and weather were suitably chosen the risk of discovery would be minimal. Many such instances of fly tipping have in fact occurred.

341. This is not to be taken as condemning waste collectors in any special way. They might in various ways be encouraged to do it by a manufacturer who does not know what to do with his waste, or by a tip operator who does not care where it goes so long as he does not take it. It is just that the collector operates that stage in the disposal which is most easily open to abuse and most likely to give trouble if something goes wrong. So that it is essential to safeguard this particular stage, which does not arise in the case of liquid effluents to sewers or rivers, and we have therefore no legislative parallel to help us.

342. One way of safeguarding would be to arrange for the contractor, should one be used, to be under contract to the authorising body and not the manufacturer with the waste to be disposed of. The cost of the collection would, of course, be recovered from the manufacturer. The authorising body, in the process of accepting responsibility for the disposal of the waste, would be far more interested in what happened to it next than the manufacturer who was just getting rid of the responsibility, and would therefore be more likely to detect malpractice. Moreover, in most cases a collector under contract to a unitary authority or a group of them would stand to lose far more by cancelled or unrenewed contracts than he would if under contract to a single firm. He would therefore be expected to take greater care in fulfilling his contract. Such an arrangement could work smoothly enough in normal circumstances, but might result in loss of valuable time when waste is produced which cannot be accurately foreseen—for example as a result of a fire or process control going adrift—and which must be cleared from industrial premises quickly. We can only suggest that if the authorising body and not the industrialist controls the collection of waste, as this paragraph envisages, then it should be recognised that emergency demands on it will arise and that it will be necessary to "cut corners" in waste disposal just as it is necessary in other fields immediately affected.

343. Another method for consideration is the licensing of contractors and/or their vehicles for the carriage of certain toxic or dangerous wastes. We are sure that this is a matter as much or more for the Ministry of Transport than for us, and this prevents our making a recommendation. Nevertheless, we would point out that the licensing of vehicles for use in certain ways is not a new idea but is operated widely, and that the carriage of certain toxic wastes may be just as dangerous and in need of control as the carriage of toxic materials which are not waste. We have been told that sometimes the physical condition of vehicles carrying toxic waste leaves much to be desired. Licensing could presumably deal with this situation which is not, however, our direct concern. Licensing could

also improve the standard of performance if serious departure from instructions on toxic waste disposal were made to result in loss or suspension of licence.

344. We think there are some wastes which are so toxic or otherwise dangerous that they warrant a certification procedure to ensure that they arrive at their proper destination. If transport were by firms' or disposal operators' vehicles a single certificate regarding the transference of ownership would be adequate, but if an intermediate contractor were used two would be necessary. The first would be a receipt given by the contractor to the firm regarding place of loading, type of waste, weight (or other approximate quantitative description) and time. The second would be a receipt by the disposal site operator giving quantity, time and where it had been received. The two certificates would meet at the authorising body's office and comparisons of recorded weights and times would ensure that no "manipulation" of any kind could have occurred while the waste was in the charge of the contractor. Wastes meriting such certification would be decided upon by the authorising body, and the requirement would presumably form part of its consent to accept the waste for disposal.

345. We do not positively recommend any of the above. We are impressed with the desirability of making the disposal of wastes as simple and straightforward as possible consistent with safety and good order. We believe that too many precautions may even be inimical to these matters, and that the development of adequate and reasonably available disposal facilities would favour them. We believe that experience will be the best guide to how far to go in controlling collection, but we think that the legislation which will be necessary anyhow should permit the appropriate bodies to adopt methods of control as experience may suggest, without having to return to Parliament for the authority, though an Inquiry and Ministerial Order might be thought necessary.

346. We have not considered in detail safeguards to be adopted during transport of toxic waste from source to disposal site. Clearly accidental spillage (unless the situation is capable of remedy) is equivalent to disposal at an unsuitable or dangerous site and is accompanied by the same or even greater dangers to rivers and water sources. Every care must therefore be exercised to prevent accidents resulting in spillages. But the dangers in transport of loads of toxic waste are no different in kind from those in transport of toxic useful materials which are taken about the country by tanker, lorry or pipeline in vast quantities. We understand that accidental spillages of these are by no means infrequent. We are informed that there is in existence a Home Office Standing Advisory Committee on Dangerous Substances which among other duties is considering the conveyance by road of dangerous materials. In our view the precautions to be taken in the transport of toxic wastes should be similar to those taken in the transport of other toxic materials of similar nature. They should include if necessary such matters as the use of suitably designed vehicles, the labelling of their contents, instructions about procedure in case of accidents, even the route to be followed in some cases to avoid spills in specially dangerous places, and so on. We think this could be most easily secured, in the case of toxic wastes, by conditions attached to the consent to disposal, and these could be worked out when necessary from the recommendations (when they become available) of the above Committee and related to the specific wastes under consideration.

347. It would presumably be made an offence for a firm to dispose of industrial wastes (except exempted wastes) for which no authorisation existed, or to hand

over those wastes for disposal either to a contractor or tip operator or others in charge of waste disposal facilities. It would also be an offence for a contractor to dispose of, or offer for disposal, a waste at a site not covered by the authorisation. It should be an offence, with a much greater penalty, for a firm or contractor to dispose of waste at a site not used for waste disposal of any kind. It would also be an offence for a disposal operator (or an official of a waste-producing firm, a contractor or his employee, or an employee of a local authority) to receive for disposal at a site waste which he had reason to believe was of a nature not authorised for that site. The exact details would need to be worked out with those with experience in legal affairs, but they should bear in mind that, in addition to making it an offence to dispose of the waste in ways and at sites other than those authorised, each blameworthy step along the line of disposal should be punishable. Then, if a contractor disposed of an unauthorised waste somewhere, the firm handing it over to him knowing it to be unauthorised would be penalised too. At the same time, we do not wish to create a situation which would encourage an all-round conspiracy of silence if disposal is carried out by wrong methods.

348. The penalties should be large, and where two parties are involved it would be for the Courts to apportion the blame and penalties accordingly.

349. We do not press the detail of the two preceding paragraphs, because we believe that the operation of safe and satisfactory disposal schemes depends not so much on the creation of offences and appropriate penalties but upon education, good will, co-operation and a general acknowledgement that waste disposal in these days inevitably costs money. Nonetheless, offences and penalties there must be.

350. Co-operation will, we believe, be best achieved if a firm is completely frank and open with the authorising body or its technical officers about the wastes it produces and how they arise and are dealt with in the factory. Such frankness is particularly desirable if the firm produces more than one type of waste and requires different authorisations for disposal in different ways or on different sites. To welcome the appropriate officers of the authorising body to the works and show them how the different wastes are produced, segregated and loaded might do much to facilitate reasonable authorisation being granted. At the same time, there are such things as industrial secrets and there is such a thing as industrial espionage, so we can appreciate that some firms would be reluctant to allow outsiders unrestricted access to their activities, particularly as the outsider (the authorising authority) will need to consult with other bodies such as river authorities and water authorities about authorisation. There is, of course, the same difficulty in regard to liquid wastes, but it is less acute because liquids can be more readily sampled and analysed and it is thus less necessary for the authority receiving them to know how they have been produced. It is also practicable (and usual) to sample where they leave the factory premises, but this would be difficult in the case of a lorry containing solid waste, which has necessarily been loaded while inside the factory curtilage.

351. Even so, both the River Pollution Prevention Act of 1961 (Section 12) (in Scotland the Rivers (Prevention of Pollution) (Scotland) Act 1965 Section 11) and the Public Health Act of that year (Section 68) make disclosure of certain types of information received under the Acts an offence. This would be even

more necessary in the case of information in respect of solid wastes, and the provision might have to include disclosure by officers of "interested" bodies who received the information from the authorising body so that they might give their views on policy. If this were not so, disclosure to the interested bodies might have to be made an offence itself, in which case they would have to express their views without knowing all the facts.

352. It may be that this clash between the perfectly proper concern of industry to prevent details of certain processes getting into the hands of competitors, and the perfectly proper demand of the authorising body to know the nature of the waste and how it arises, will never be solved by legislation. Certainly, officers of the authorising bodies and disposal organisations would need to be subjected to such restrictions as are in the Acts quoted in the preceding paragraph, but beyond that there might have to be local arrangements. For instance, an industrialist might believe that a disclosure of certain information would convince an authorising body that a relatively cheap method of disposal would be satisfactory; without it a more expensive method might be insisted upon because of the properties the waste *might* have. If he felt that he could not disclose the information because of the risk of its reaching competitors, then the extra cost of disposal would be part of the price he would pay for retaining the commercial advantage of secrecy. Again, it might be possible to agree locally that an authorisation could contain a condition that certain officers should have access to certain parts of the industrial premises.

353. We have said earlier that we think it would be advantageous if refuse disposal authorities accepted more toxic solid industrial wastes for disposal than they do now. We doubt if legislation is necessary to permit them to do this, but if it is then it should be provided. It should only be permissive and not compulsive in character; the right balance between industrialists, contractors and local authorities as disposal agents will work itself out gradually, assisted maybe by some decisions of the Minister on appeal.

354. We have also said that in many cases some unitary authorities ought to work together in these matters. This applies particularly to the appointment of highly-qualified experts to advise them on questions of authorisation, to check that authorisations are being complied with, and to superintend the disposal of particularly dangerous wastes, and in areas where two or more contiguous authorities are complementary to each other in disposal facilities. Legislation could be required on this point. Arrangements would also need to be made for collaboration among authorities which have, and those which have not, special facilities within their areas, including deep dry mineshafts and special incinerators.

355. It has been assumed throughout that the authorising body would need to consult with the river and water authorities in the neighbourhood, and this should be mandatory for all non-exempted wastes it is proposed to tip. Their interests are so important, particularly when the water at risk constitutes an underground source of supply. But we do not think their influence should extend so far as to be able to veto a proposed method of disposal. The responsibility should lie entirely with the authorising body, and its decision should take into account the known information on all factors, including risks to water, other risks, the waste itself, the facilities available and the precautions to be taken.

356. However, although we have concluded (para. 307) that river authorities, having but a single interest in toxic waste disposal, namely protection of water, should not themselves be authorising bodies, we are well aware of the great importance of their interest. We feel, therefore, that they have a right, just as producers of toxic wastes have a right, to be protected against what they may regard as unreasonable decisions of the authorising body. The waste producer will have a right of appeal against unreasonable refusals, or consents with too restrictive conditions (para. 335), so the river authority should have the right to appeal against what they believe to be unreasonable consents or consents with inadequate restriction. Clearly, the time allowed to the river authority for making such appeals after an authorisation has been given should be quite short, and this would mean that in fairness to them they should be informed of authorisations when the waste producer is informed about them. We see no objection to this. We may also mention here (though we are anticipating, see para. 358) that sometimes it may be necessary to review or cancel an authorisation. This might well be on representations made by the river authority, based on experience of the effect of the disposal as authorised, and we think it would be desirable to permit that authority to appeal against the refusal of the authorising body to renew or cancel an authorisation. We would not regard this as merely multiplying cases into which the Minister could be brought. It would more probably reduce the number of appeals, because a river authority would be less likely to appeal against what it might think to be a risky authorisation if it knew it could take action when any evidence came to light, and with greater prospects of success too, precisely on that account.

357. Sometimes the officer responsible for advising on authorisation would feel the need for advice from people with greater knowledge than his own, and we think that his need for a "second opinion" should be satisfied. This could take the form of a technical advisory committee, members of which should all have a wide experience of waste disposal problems, and amongst them should be individuals sufficiently well qualified in river chemistry, water chemistry, air pollution, geology, engineering, biology, toxicology, public health and research, etc. We doubt if it is necessary to make this a statutory committee, but it should be set up under the aegis of the Minister of Housing and Local Government. Its purpose would simply be to offer advice to authorising bodies, but not to make the decisions for them. It would not speak in the name of the Minister, who would not therefore be prejudiced should there be an appeal, nor would it discuss cases likely to lead to an appeal in the presence of an Inspector who might have to hear it.

358. There remains the problem of how to ensure that authorisations are conformed with; how to check that supposedly inert wastes not needing authorisations are in fact inert wastes; how to be sure that wastes authorised for incineration are not in fact (accidentally or maliciously) tipped. We think it should be a duty of the authorising body to satisfy themselves on this point, but in any event they will no doubt feel they must do so because otherwise it will be impossible to differentiate between trouble (if any) arising as a consequence of authorisation, and that arising from non-compliance with it. One of the big problems here is that any system which is too cumbrous soon comes into disrepute and tends to be ignored. We feel sure that if a firm—or an operator—really decided to save a little money—or make a little money—by illicit disposal of waste, then by

sufficient thought and precautions they could do so with only a minor risk of being discovered. This sort of thing cannot be completely stopped. It would be made much more rare, we believe, by legislation along the lines we have described in this chapter and by making the penalties for unauthorised disposal severe—more severe than for first offenders under the River Pollution Prevention Acts. In addition, attention to the following practical matters would discourage illicit tipping and ensure that authorisations are generally conformed with:

a. by authorising disposals by as cheap a method as possible having regard to the toxicity and other matters. The more difficult and expensive disposal is made the more likely it is that illicit disposal will occur. To compel too great a degree of safety may result in greater danger;
b. by informing waste collectors (private or municipal) of the names of firms which produce wastes which have needed authorisation, and of those which produce wastes which are not authorised to be tipped;
c. by occasionally sampling wastes being received, particularly at tips, to ascertain, not their exact analysis, but whether or not they are the type of refuse for which authorisation has been given;
d. by arranging that, in the case of tips carrying the greatest risk, all deliveries shall be accompanied by a certificate, dated and timed, saying from what firm the waste has come, giving appropriate information as suggested in paragraph 344, and signed by a representative of that firm.

359. We have given some consideration to such matters as the permissible content of authorisations, whether or not they should be cancellable or alterable in any other way, whether a tip, for instance, should be authorised to receive wastes in stated categories, or whether in every case special authorisation of a waste would be necessary, and the specific problem of wastes arising in a manner not foreseen and in circumstances where any delay in disposing of them would be embarrassing, unduly expensive, or disastrous.

360. We have come to the conclusion that there should be a good deal of flexibility in these matters, which would facilitate local arrangements which best suited the circumstances. We mention the following as examples of the diversity of arrangements which could, in given conditions, be appropriate and should be made permissible.

361. Some wastes are produced in large quantities without substantial change over many years, but may fail to find inclusion in any general class of exempted waste. It may be quite plain and accepted by everybody that a given site for tipping will be perfectly safe and could indeed be reserved for that waste. In that case the planning consent for the establishment of the tip could be, virtually, authorisation for that waste to be tipped there to the limit permitted by the planning consent. There would be no need of cancellation before then, and no need (except formally if necessary) for authorisation of the waste. On the ground that the arrangements should be as simple as possible this one should come within the law.

362. Some wastes which are regularly produced might appear dangerous to tip indefinitely at the desired site without obtaining assurances, by analysis or otherwise, that disposal is in fact being made safely. In these cases authorisation could properly be for a given quantity over a given period only, or made subject to review and possible cancellation at, or any time after, a specified date. The

review or cancellation clause in the authorisation would not be open to appeal except before the authorisation is taken up, otherwise dangerous conditions might set in while the appeal was being dealt with.

363. Some wastes which would normally be mixed may contain, on occasions, a small quantity of a much more toxic waste from a special process. It should be permissible to authorise disposal by a given method provided the extremely toxic waste is excluded, and provided the authorising body can be satisfied about this by inspection or otherwise. Such arrangements might well be profitable to both sides, and should be permissible under the proposed legislation.

364. Mention has already been made in the section on waste collection, of wastes arising during emergencies which can scarcely be foreseen. It is, of course, a manufacturer's duty to make reasonable provision for emergencies, but he can hardly be required to anticipate every conceivable eventuality. Consequently, there will be on occasions quite unexpected wastes, some highly toxic. In common with other emergencies, such a situation will have three "properties". It will need to be dealt with quickly; it may not be possible to adopt what later consideration may show to be the cheapest way of dealing with it; and it may not be possible to take what precautions idealism would call for. The organisation set up to deal with industrial waste authorisation and disposal should be such that emergencies of this nature can be met and dealt with having due regard to all these desiderata—speed, cost and safety—in the optimum way.

365. A few wastes may be of such a character, and the disposal facilities in the authorising body's area so limited, that disposal cannot be authorised anywhere within its area although a neighbouring area could readily accept it. Similarly, a waste needing authorisation may be produced near the boundary of an area in close proximity to a safe and economic disposal site in another unitary area. In some cases, such a situation would be dealt with as a matter of course because the two areas would be working together as part of a group and authorisation in the most suitable way, irrespective of area, could be given. But this would not always be the case, and where two independent authorising areas are concerned we would want technical and economic considerations to prevail over administrative and local political considerations. We hope this will be made possible, even encouraged.

366. These examples of situations which will arise could be multiplied but more need not, we think, be said to establish that legislation, necessary though it is to control toxic waste disposal, should permit a great deal of flexibility in arrangements which may be made.

367. The fundamental change which our proposed legislation would bring about would be the establishment of an authorising procedure with the Greater London Council, the proposed metropolitan areas, the proposed unitary areas, singly or in groups, for England, and corresponding bodies in Wales and Scotland, as the authorising agents. Clearly this cannot be brought into operation until those metropolitan and unitary areas have been created, and this has still to be done. It seems reasonable, however, to hope that the legislation we propose will be passed in time for the new authorities to take up their additional duties as soon as they come into operation.

368. If, for any reason, the proposed authorities are not created, or if there is a long interval between their creation in England, Wales and Scotland, then we

think it would be necessary to set up some kind of authorising bodies meanwhile, and this too would require legislation. We think this could be along the lines of the English Local Acts we have mentioned. This would give the county council or county borough council the right and duty of saying how specific toxic wastes should be disposed of, subject, where appropriate, to the agreement of the refuse disposal authority where this is not the council mentioned. This arrangement would be by no means ideal, but if it worked as well as it has done in parts of England it would be a considerable advance on present arrangements.

Authorisation of sea disposal

369. Special arrangements will be needed to cover sea disposal, not only because many unitary authorities would not have access to it within their areas, but because entirely different interests are brought in and authorisation could not always remain the duty of any unitary authority. Within limits, and providing the situation is not abused, we believe it would be satisfactory for authorities which are also sewage disposal authorities to discharge some toxic aqueous liquids and solids to sea mixed with their sewage and particularly with their sludge, the only obligation being to consult either a Sea Fisheries Committee or the Ministry of Agriculture, Fisheries and Food on matters of general policy. Discharge of toxic solids to sea separate from sewage within the 3-mile limit is, in our view, extremely rare, though discharge of toxic liquids does take place and it requires the consent of a Sea Fisheries Committee. This we would not change. Beyond the 3-mile limit there is no authority whose consent to disposal is legally necessary. So far as we can see, if consent were made necessary the Ministry of Agriculture, Fisheries and Food would be the only appropriate body. If it were given the formal responsibility, however, it is not clear that there could be an appeal made against its decisions, and with other wastes and methods of disposal the appeal to the Ministry of Housing and Local Government has been such an important safety valve and reference point that without it present legislation might never have been passed. We have, however, already noted that the present voluntary consent system operated by MAFF is believed to be working well, and so long as this obtains we think it might well be a mistake to introduce any compulsory system and we do not recommend it. A similar arrangement applies in Scotland, where the Department of Agriculture and Fisheries for Scotland is consulted.

Chapter XXVII—Summary, Conclusions and Recommendations

(The numbers in brackets refer to paragraphs in the Report)

(1) Because of the difficulty of defining the term "toxic", and because some liquid wastes are disposed of in the same way as solid wastes and give rise to similar dangers, our investigation has covered a somewhat wider field than our terms of reference would suggest. (Paras. 2–6.)

(2) For the same reason, the statistics we have collected to illustrate the magnitude of the problem are offered with great reservation. It appears, however, that the annual production of toxic solid and semi-solid wastes in Britain is some hundreds of thousands of tons and that the present cost of disposal is a few million pounds annually. (Paras. 34–37.) In addition, large quantities of liquid wastes unfit to discharge to sewers or rivers are disposed of largely to tips. (Paras. 194–197.)

(3) The wide variety of toxic waste is illustrated, and there are many more types which may not be properly described as toxic but which could give rise to similar problems almost as serious. (Paras. 32 and 33.) Our recommendations apply to these too.

(4) Almost all toxic solid wastes are disposed of by tipping, with minor quantities being incinerated or discharged to the sea. The tips are owned and operated chiefly by firms producing the waste and by specialist contractors who make waste disposal their business. (Paras. 40–49.)

(5) A selection of cases of water pollution from toxic wastes which have occurred in Britain is given. Cases of water abstracted from underground for drinking being polluted have been very rare. Cases of river pollution have been more frequent, but by no means as common as might have been expected. Because of the time-lapse between tipping and the possible appearance of pollution this is not as reassuring as it might be; in any case, production of toxic wastes seems bound to increase. (Paras. 53–56.)

(6) It is plain that there are important natural barriers to pollution between a tip and underground water. Unfortunately these cannot be relied upon for all wastes, though it is right to make use of them. (Paras. 20–22.)

(7) Other risks of disposal by tipping, including fire, air pollution, explosion, effect on trespassers and on animals which may spread the risk, and on re-excavation, are discussed. (Paras. 58–64.)

(8) The development of present-day organisation of industrial waste tipping is narrated, and the functions performed by the waste producer, transport con-

tractor, tipping contractor and local authority are described and analysed. The part played by local authorities is a minor one. (Paras. 72–91.)

(9) One of our conclusions is that the present system offers too many opportunities to those who are concerned to get rid of waste rather than to dispose of it safely. Fly tipping does occur and can often be done with little risk of detection; but the results can be and have been very serious. Among the ways of reducing its incidence is the provision of better facilities for proper and safe disposal. (Paras. 88–91.)

(10) The law relating to waste disposal is summarised. We have included that relating to liquid industrial wastes discharged to sewers and rivers because of the parallelism which we feel could exist between that and a comprehensive code of law governing solid wastes, particularly industrial toxic ones. We do not think the present legislation on toxic solid wastes is adequate, and have referred to some local Acts which may show the way. (Paras. 92–128.)

(11) We have considered the processes which must take place before tipped toxic materials can reach either rivers or water for supply, bringing out the importance of rainfall, tip management, geological factors, hydraulic gradient, distance between tip and water source, and size of source. (Paras. 129–151.)

(12) Because there must be some relationship between travel of percolate from house refuse and that from toxic waste tips, we have summarised some fully controlled tests made on the former and published in 1961. (Paras. 152–159.)

(13) We conclude that the method of operation of a tip could be such as to increase or diminish greatly the risk of contaminants leaving it. Some precautions might be merely matters of day-to-day operation; others could be quite expensive projects carried out before tipping starts or after it is completed. Among methods of preventing, or at least reducing, the amount of percolation, are good consolidation of the toxic material in depth (Para. 161), less consolidation of surrounding inert wastes (Para. 162), tipping the toxic material in depth (Para. 163), waterproofing the base of the tip (Paras. 166 and 167), covering the completed tip with a waterproof layer (Para. 168), and taking advantage of sites, including existing house-refuse sites, which have already been shown by long experience to be safe. (Paras. 172–179.) There may also be a place for the establishment of special above-ground tips. (Paras. 169 and 170.)

(14) We have examined the possibility of pre-treatment, including reclamation of useful materials, of toxic solid wastes before disposal. The subject deserves more attention than strictly economic considerations would dictate, but is limited in scope. (Paras. 180–188.)

(15) Sludges from pre-treatment of liquid industrial wastes even though properly described as toxic, present little risk of water pollution when tipped on sites safe from other angles. It is suggested that local authorities could play a bigger part in disposing of such wastes. (Paras. 189–193.)

(16) The disposal of aqueous liquids on tips is practised on a greater scale than is generally realised, and appears to be growing rapidly. Seeing that the obvious safeguards in tipping to reduce the risk of water pollution are not available when tipping liquids, we believe that the practice is intrinsically more dangerous than the tipping of toxic solids. (Paras. 194–201.)

(17) Nevertheless, we are aware of places where it has been taking place for long periods without trouble, and in such cases we see no reason to object to its continuing. In general, however, we believe that other methods of disposal are to be preferred and that, when tipping needs to be considered, the evidence for the safety of the site should be very strong before the practice is adopted. (Paras. 202–211.)

(18) Industrial, oily and tarry wastes present another special problem. We do not favour the tipping of these wastes in principle, but recognise that sometimes it may be inevitable and on some sites perfectly safe. More consideration should be given to reclamation and incineration, and there is also scope for the use of deep, dry abandoned mines where they are available. (Paras. 212–217.)

(19) There is a limited outlet for the disposal of toxic wastes with sewage sludge where this is not used for agriculture. (Paras. 218–220.)

(20) For organic toxic wastes, incineration has the outstanding merit that it destroys toxicity. But it is neither simple nor cheap, and air pollution must be prevented. We look for an increased use of incinerators, both purpose-built ones and, in a limited way, those used for house refuse. (Paras. 222–238.)

(21) Wastes which are too dangerous to abandon anywhere, but which need to be retained permanently in safe and accessible storage are rare indeed, and we doubt if there is a need for providing such storage for the type of waste we are considering. (Paras. 239–242.)

(22) Disposal to sea, by such techniques as will ensure that the immense potential dilution is utilised, and for such wastes as are never likely to be re-concentrated, is safe and satisfactory. It should not be abused, but regarded as complementary to disposal on land so that optimum overall safety can be achieved. The voluntary consent system for deep sea disposal operated by the Ministry of Agriculture, Fisheries and Food is working satisfactorily. (Paras. 243–253.)

(23) Occasionally, sudden arisings of very small quantities of very toxic wastes present difficult and almost embarrassing problems; we believe local authorities could often help. (Paras. 254–258.)

(24) Little scientific research on methods of disposal of solid toxic wastes has been carried out. It is difficult, in fact, to see what systematic and fundamental studies would comprise. But we believe that investigation, both of experience and by experiment, is necessary on a continuing scale. We think that a small team of workers to do this should be set up by the Water Pollution Research Laboratory. (Paras. 259–265.)

(25) We accept that economics as well as safety must be taken into account in deciding methods of waste disposal. The ideal is, however, defined, and practical policies are then outlined for different sets of circumstances. Such policies are, in our view, more likely to ensure safety (being less likely to be evaded) than strict idealism. (Paras. 266–278.)

(26) Ways of greatly improving present toxic waste disposal practice are described and recommended. (Paras. 279–302.)

(27) We have been led to the view that the proper application of these methods to particular cases would best be ensured if the method and technique of disposal

were specifically authorised by some body with adequate technical and local knowledge and financially independent of what is decided. (Para. 304.)

(28) We found it easy to say who the authorising body should not be (Paras. 305–314). After the publication of the Redcliffe-Maud Report on Local Government in England and its acceptance in principle by the Government, we concluded that the authorising bodies should be (a) the Greater London Council (Paras. 316 and 317), (b) the proposed Metropolitan Councils, and (c) the proposed Unitary Authorities, acting singly in the case of some of the larger ones, but suitably grouped in the case of those whose resources (in facilities and finance) are smaller. This we recommend (Paras. 319–324). We also recommend comparable arrangements for Scotland and Wales (Paras. 326 and 327). We discuss possible action should the creation of such bodies be long delayed or abandoned. (Para. 368.)

(29) Legislation will be necessary to put these arrangements into effect, and we have indicated, without going into detail, what we believe this should provide for. Our aim would be to bring disposal of toxic wastes under adequate control so that it is safe and satisfactory but, at the same time, to give all parties sufficient freedom of manoeuvre so as to arrive at the optimum overall solution in a particular case without being inhibited by restrictions which, for that case, would hinder rather than help. (Paras. 328–369.)

(30) Because of the difficulties of definition we agree that the legislation should apply in principle to all industrial wastes, solid and liquid, and that there should then be excluded those which can be precisely defined and which are dealt with in other legislation or are inert. Examples are given, one of which would, of course, be liquid waste if disposed of under the Public Health Acts and River Pollution Prevention Acts. (Paras. 329–334.)

(31) Apart from these, disposal by any proposed method and at any proposed place should require authorisation, which should be given (with conditions if necessary) or withheld, on the basis of information supplied (often in confidence) by those councils to be set up which have the duty of refuse disposal. There would be an appeal to the Minister in case of refusals or consents held to be unreasonable. (Paras. 335–337.)

(32) It would be a duty of the authorising body, before it arrives at a decision, to consult with appropriate bodies and, in particular, in the case of proposed disposal by tipping, with the river and water authorities. (Paras. 355 and 356.)

(33) It would also be a duty of the authorising body to check that disposal is properly carried out and that any procedures laid down for ascertaining the effect of the waste were followed. It should be given authority to reserve the right to review or withdraw its consent. (Paras. 358–366.)

(34) A non-statutory central technical advisory committee should be set up to assist in specially difficult cases. (Para. 357.)

(35) Many of the details of the proposed legislation could profitably run parallel to corresponding matters in the laws relating to liquid wastes. (Para. 338.)

(36) It will also be necessary to make suitable provision to ensure that conveyance of wastes from production to disposal sites is properly carried out. Trans-

port contractors will have to operate under provisions applicable to them. We have discussed what these might be. (Paras. 339–346.)

(37) The voluntary consent system for deep sea disposal operated by the Ministry of Agriculture, Fisheries and Food is working satisfactorily, and we do not wish to see it altered. (Para. 369.)

(38) We would emphasise that legislation and regulation cannot provide the whole answer. It is also important to foster a spirit of mutual co-operation and helpfulness, to provide more suitable and safe facilities for disposal, and not to begrudge the unavoidable cost there must be.

We have the honour to be,
Sirs,
Your obedient Servants,

Signed A. KEY, *Chairman*
A. E. BARTON
E. A. B. BIRSE
S. G. BURGESS
R. A. CUNIS
A. L. DOWNING
W. ETHERIDGE
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J. L. STRINGER
J. SUMNER
E. WINDLE TAYLOR

D. H. A. PRICE
Secretary
T. WALDMEYER
Assistant Secretary

March 1970

APPENDIX

The following bodies submitted written evidence to the Committee. Those marked with an asterisk also submitted oral evidence.

Associated Octel Company Limited
Associated Semi-Conductor Manufacturers Limited
Association of County Public Health Officers
*Association of Municipal Corporations
*Association of River Authorities
Association of Rural District Council Surveyors
Atomic Energy Research Establishment
Borax Consolidated Limited
Cambrian Chemicals Limited
*Cleansing Service (Southern Counties) Limited
*Confederation of British Industry
Contract Gully Cleansing Limited
Counties of Cities Association (Scotland)
*Edwin Clark Limited
Effluent Disposal Limited
Effluent Services Limited
Electronic Valve and Semi-Conductor Manufacturers' Association
Green, G. W. (Contractors) Limited
Harrison, C. W. (Contractors) Limited
Industrial Waste Disposals (South Wales) Limited
Institute of Water Pollution Control
*Institution of Water Engineers
John S. Young and Company (Industrial Services) Limited
Keene and Kelly (Solicitors) on behalf of a number of contracting firms
*Land Reclamation Company Limited
London Boroughs Association
Ministry of Agriculture, Fisheries and Food (Advisory Committee on Pesticides and other Toxic Chemicals)
Mitchell Thomson Limited
Mullard Limited
Pannell, A., Limited
*Purle Brothers Limited
Richard Biffa Limited
*Rural District Councils Association
Scottish River Purification Boards Association
Sweetway Sanitary Cleaners Limited
Tank Cleaners (Glasgow) Limited
*Thomas Hancock Limited
Victor Blagden (Barking) Limited

We have also received information, directly and indirectly, ranging from answers to simple queries to full statements of local policies, from a large number of local and river authorities. It would hardly be justifiable to name them all, but invidious to make a selection. We have also had correspondence with other organisations and individuals.

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J. L. Hewson, Esq., B.Sc., F.R.I.C.
Dr. G. W. Knight, M.D., D.P.H.
H. E. T. Lowbridge, Esq., F.A.P.H.I.
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T. Waldmeyer, Esq., B.Sc., F.R.I.C., M.Inst.W.P.C. (Assistant Secretary).

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